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800-TON HYDRAULIC TESTING MACHINE.

ALTHOUGH tests on specimens of the steel wire employed in the production of wire ropes are useful, the testing of the completed rope has the advantage of yielding direct information on the efficiency of the construction and method of manufacture adopted, and also of enabling the factor of safety to be decided with greater certainty. The full-scale testing of colliery wire ropes and similar equipment, however, necessitates the construction of large and powerful machines which are obviously costly, but the justification for this is that the safety of the mining personnel is directly concerned. This question of safety in mine operation was uppermost in the minds of the Association des Industriels de Belgique, Brussels, when, as a result of the opening of new deep pits in the Campine coalfield, wire ropes of larger diameter and greater strength than had previously been in service were called for. Whereas, previously, the ultimate tensile strength of the largest-diameter winding ropes used was in the neighbourhood of 200 metric tons, breaking loads of 300 metric tons were specified for the ropes for the new pits, and it was also stated that ropes having an ultimate strength of 450 tons would be required for future extensions. These developments thus rendered the Association's existing 250-ton tensile-testing machine inadequate for the work, and the acquisition of a new machine of much greater capacity was decided upon.

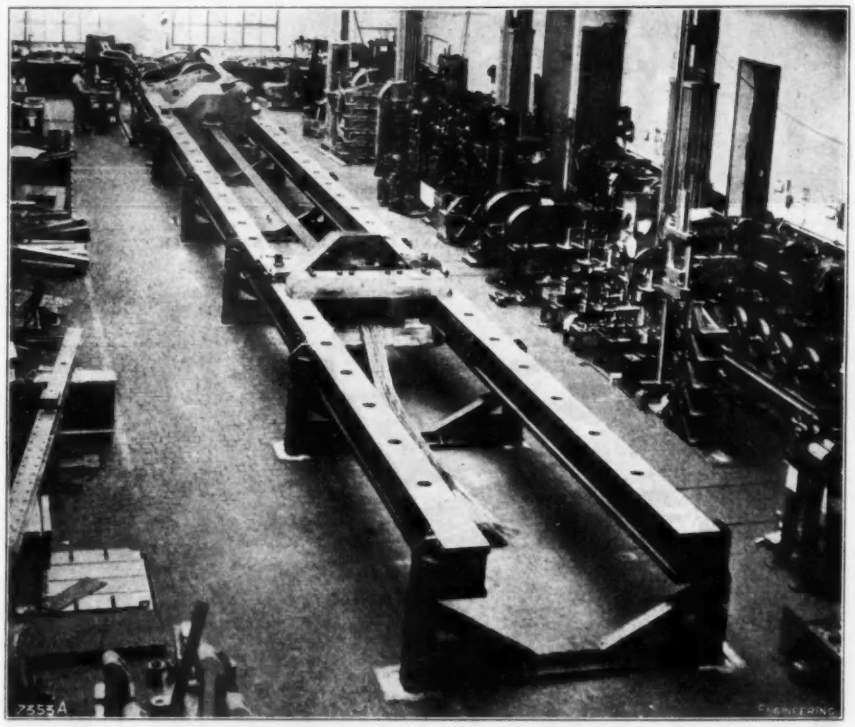

FIG. 1. MACHINE FROM REAR END.

The construction of the new machine was entrusted to Messrs. Alfred J. Amsler and Company, Schaffhouse, Switzerland, Mr. Y. Verwilst, the engineer in charge of the Association's laboratories, collaborating in the design. The machine was erected in one of the laboratory buildings of the Association, in Brussels, and after an exhaustive series of trials was placed in service in July, 1939. A general view of the machine is given in Fig. 1, on this page, and drawings of it are reproduced in Figs. 4 to 9, on Plate XIV. Figs. 4 and 5, are, respectively, an elevation and a plan of the complete machine, and Figs. 6 and 7 show the hydraulic mechanism and the front gripping head. Fig. 8 is a cross-section at A A (Fig. 6), and Fig. 9 a cross-section at B B (Fig. 6). The machine, which is operated hydraulically, is of the horizontal type and is capable of exerting a maximum pull of 800 metric tons on ropes or round bars having a diameter of up to 12 cm. (4·72 in.) and a length of up to 19·5 m. (63 ft. 11 in.). It consists essentially of a long rectangular frame, near one end of which is a fixed crosshead carrying twin horizontal hydraulic cylinders within which operate "frictionless" rams. The outer ends of the rams bear against a crosshead which is connected by means of two horizontal rods, to the front, movable gripping head of the machine. The weight of these parts is supported on ball-bearing wheels running on the two longitudinal members of the main frame of the machine. The rear gripping head of the machine, which, of course, remains stationary during a test, is also mounted on ball-bearing wheels running along the longitudinal members of the frame and it may be locked in any convenient position by means of two stout pins. The machine has an overall length of 31·5 m. (103 ft. 4 in.) and a maximum height, above floor level, of 2·2 m. (7 ft. 2·6 in.). The distance between the centres of the two longitudinal members of the frame is 1·9 m. (6 ft. 3 in.).

The main frame of the machine consists of two parallel longitudinal box-section members, made up of broad-flange beams with the webs horizontal. Placed across the flanges, and welded to them, are steel plates, the upper ones being machined and finished to provide a smooth path for the ball-bearing wheels of the gripping heads. The longitudinal members are held in position and are supported by cradles, each made up of two flexible vertical plates, stiffened by angle-iron bracing arranged obliquely, thus ensuring the transverse rigidity of the cradle which rests on concrete blocks case *in situ*. The arrangement is seen in Figs. 1, 4 and 5, from which it will be noted that free access is afforded for the introduction of test pieces and that an uninterrupted view of the specimens, while undergoing a test, is obtained.

Oil under pressure is delivered to the twin hydraulic cylinders of the machine by the oil pump seen in the foreground in Fig. 2, on page 202. It is driven by an 11-h.p. electric motor. On the left-hand side of the pump in Fig. 2 is seen the oil-supply tank, into which the oil is returned at the conclusion of a test. The two cylinders of the machine are interconnected and a single pipe supplies oil for operating the two rams, which are identical in diameter and have a maximum stroke of 2 m. (6 ft. 6 in.). At the conclusion of a test the rams are returned into the cylinders by means of a small auxiliary cylinder placed between the main cylinders, the position of this cylinder being shown in Fig. 8. It is connected to an oil distributor and is employed to adjust the position of the main rams when these are not under load. In this manner the rams can be moved either outwards or inwards and stopped in any desired position. During a test the auxiliary cylinder is by-passed and does not interfere in any way with the application of the load. As has been the case with Amsler mechanical testing machines for many years past, the load applied to the test-piece is measured and recorded by means of a pendulum dynamometer seen on the right of the oil pump in Fig. 2. The principle of this instrument is well known; it was fully described and illustrated in ENGINEERING, on page 354, vol. 106 (1918), and more recently on page 355, vol. 130 (1930). Briefly, when the load is applied to a specimen, the pressure oil operates a small piston which deflects a weighted pendulum by a system of rods and levers. The movement of the pendulum is indicated on a dial and recorded on a paper-covered drum. The pendulum can be suspended from four different points which enables loads to be measured up to maxima of 100, 200, 400 and 800 tons with the same degree of accuracy in each case. The accuracy is guaranteed to within ± 1 per cent. for all loads above one-tenth of the maximum load in each range. By the use of an oil-delivery regulator and the manipulation of a control valve on the dynamometer, the load may be applied at any desired uniform speed up to the maximum of 7 cm. (2¾ in.) per minute.

Great care has been taken in the design of the gripping heads, shown in Figs. 12 and 13, on page 203, and also in Figs. 14 to 17, on page 210, and Figs. 6 and 7, on Plate XIV. The grips comprise either two or four pairs of wedges, according to the shape and nature of the test-piece. Each pair consists of an outer and an inner wedge of different taper, the angle of taper of the inner wedge being smaller than that of the outer wedge. When, therefore, a tensile stress is exerted on the specimen, the inner wedges are drawn forward by the test piece to a greater extent than are the outer wedges, which are only capable of slight movement in the gripping head. Hence, the forward movement of the inner wedge, within the outer wedge, causes the specimen to be gripped firmly. When it is desired to test a steel-wire rope of circular section, or similar specimen, four pairs of wedges are employed, arranged in the manner shown in Fig. 15, on page 210. In order to protect the portion of the surface of the rope held in the grips, strips of relatively soft material, such as wood or copper, are inserted between the specimen and the inner wedges. When the load is applied, the forward movement of the inner wedges forces the rope into the soft material and the surface remains undamaged. Another method which may be employed is to cap the ends of the rope with a low melting-point alloy; the strips of soft material between the specimen and the inner wedges may then be dispensed with.

When it is desired to carry out tensile tests on flat steel cables only two wedges, an upper and a lower, are employed, and between them are inserted two thick plates. The backs of these plates are convex, thus enabling the specimen to be held securely even if there is inequality in thickness across the width of the steel cable. The arrangement is shown in Fig. 16, from which it will be seen that, in this case also, strips of relatively soft material are inserted next to the specimen to protect its surface. It will, moreover, be noted that the space left by the removal of the lateral grips enables wide cables to be tested; actually, the maximum width of cable of this type which can be accommodated in the machine is 50 cm. (19·7 in.). Flat steel bars measuring up to 20 cm. (7·78 in.) wide by 4 cm. (1·57 in.) thick can also be tested, and the maximum load which can be applied to bars of this type and to flat steel wire ropes is 400 tons. Tensile tests on chains are conducted by means of the U-shaped grips, shown in Fig. 17, which may be adjusted within wide limits for the testing to destruction, or the proofing, of chains of many types. The maximum load which the machine is capable of applying to chains is 400 tons, and the maximum overall width of link

and diameter of bar forming a link, which can be accommodated, are 22 cm. (8·66 in.) and 6·5 cm. (2·56 in.), respectively.

At the end of a test, when either the test-piece has been broken or the load on it has been removed, the inner and outer wedges of the gripping heads usually come away readily from the specimen. This is especially the case when the test piece has parted, as the shock due to the fracture tends to knock the wedges out of the gripping head. This backward travel of the wedges, however, is cushioned by the two timber cross-pieces, shown in Figs. 4 and 5. In the case of the rear grips, these cross-pieces are bolted to the frame of the machine, as seen in Figs. 1 and 12, and in the case of the front grips, on to the two horizontal rods, which transmit the force exerted by the main hydraulic rams to the movable head, as seen in Figs. 3 and 6. If, however, there should be difficulty in releasing the wedges, they may be withdrawn by rotating pinions on the gripping head, which engage with racks fitted to one side of each of the four outer wedges, as seen in Fig. 14. This system has the further advantage of giving great flexibility in the manipulation of the grips, and is particularly useful when the thickness of the specimens to be tested varies within wide limits.

Compression tests may also be conducted in the machine and the equipment for carrying them out is shown in Figs. 10 and 11, opposite. As will be obvious from Fig. 10, the test pieces are inserted between two flat plates mounted in spherical seatings, one secured to the back of the stationary crosshead carrying the hydraulic cylinders, and the other bolted on to the back of the movable gripping head. The two flat plates each measure 52 cm. (20·5 in.) square, and the maximum distance between them, *i.e.*, the longest compression test-piece which can be accommodated, is 2·5 m. (8 ft. 2 in.).

The total weight of the machine is about 90 metric tons, and, when it exerts a tensile force of 800 tons, which, as the result of the breakage of the specimen, suddenly falls to zero, its component parts are subjected to considerable shock. Hence, the foundations, in addition to carrying the deadweight of the machine, must be capable of withstanding heavy impacts, and, in consequence, particular attention was given to their design and construction. As already stated, the two parallel longitudinal members, forming the main frame of the machine, are supported on five flexible cradles. These, which are bolted on to blocks of concrete cast into the ground, are subjected to elastic deformation under the impact stress set up by the fracture of a specimen and absorb the energy transmitted to the frame. The portions of the two longitudinal members adjoining the hydraulic-cylinder crosshead and the movable gripping head are supported on short posts mounted in spherical housings which allow slight movement to take place when a specimen breaks.

The heaviest portion of the machine, however, is that incorporating the stationary crosshead on which the hydraulic cylinders are carried and the movable crosshead and rods which transmit the load to the front gripping head. The inertia of these parts is high, and the impact due to the energy released by the fracture of a test-piece is correspondingly great. As is shown in Fig. 8, on Plate XIV, the base of the stationary crosshead is formed with three longitudinal projections which enter corresponding recesses in the concrete foundations. Furthermore, the base is held in a shock-absorbing frame, made up of two stout timber beams placed some distance apart, as shown in Figs. 6 and 7, and held together by six long steel tie-rods running in pairs in the three recesses in the concrete. The beams are housed in two transverse troughs in the concrete and are securely held against the sides of the troughs by the tie-rods. The projections in the base of the cylinder-carrying crosshead bear, on the one hand, against the beam situated immediately below it, and, on the other hand, on distance pieces which, in turn, press against the other beam. The whole arrangement is clearly shown in Figs. 6 and 7. It will be understood that the impact due to the breakage of a specimen is transmitted to the shock-absorbing frame, and this causes a slight lateral movement of the beams in their transverse troughs, with consequent elastic deformation in the six tie-rods. When the effect of the impact has been absorbed, however, the frame is returned into position owing to the elasticity of the tie-rods. The slight lateral movement of the wooden beams has the advantage of deadening the noise of the impact, as it is caused only by the sliding of timber over a concrete surface. We are informed that exhaustive trials have shown the shock-absorbing equipment to be entirely satisfactory.

800-TON HYDRAULIC TESTING MACHINE.

MESSRS. ALFRED J. AMSLER AND COMPANY, SCHAFFHOUSE, SWITZERLAND.

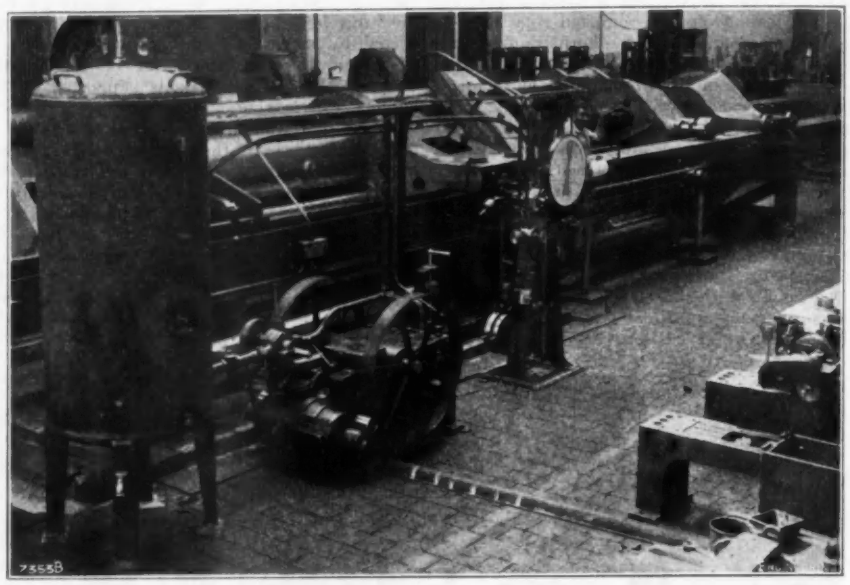

FIG. 2. OIL TANK, PUMP AND PENDULUM DYNAMOMETER.

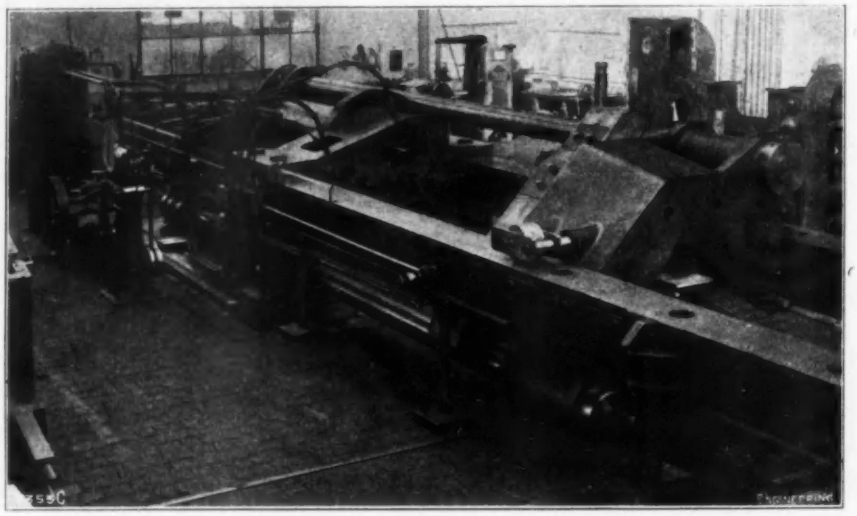

FIG. 3. HYDRAULIC CYLINDERS AND MOVABLE HEAD.

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ENGINEERING INSTITUTIONS AND LOANS TO THE GOVERNMENT.—The Institution of Chemical Engineers has decided to lend 2,000*l.* to the Government, free of interest, for the duration of the war. The Institution of Production Engineers has made a similar loan to the Treasury, without interest, of 1,000 guineas, this being the excess of income over expenditure for the financial year ending June 30, 1940.

LITERATURE.

Sound Transmission in Buildings: Practical Notes for Architects and Builders. By R. FITZMAURICE and W. ALLEN. London: H.M. Stationery Office. [Price 4*s.* net.]

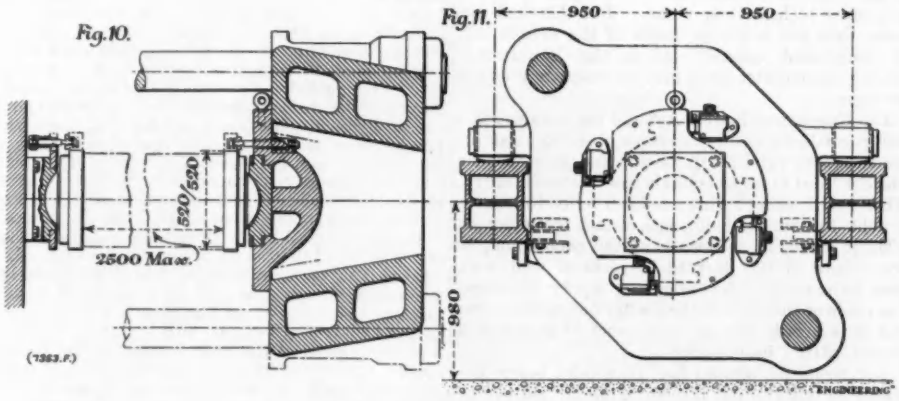
FOR a number of years, the accounts in ENGINEERING of the activities of the Building Research Station and the National Physical Laboratory have followed the progress of the work on architectural acoustics which has been carried out jointly by these two establishments. Among the numerous branches of this wide subject, that which aims at the abatement of noise in buildings of the domestic type, such as dwelling houses and offices, has received particular attention as the result of the practical interest taken by the Ministry of Health in the construction of working-class flats. It has been systematically studied, firstly, as regards the transmission of noise through the separate elements of the fabric of a building, secondly, to determine the interaction between walls, floors and ceilings, and finally, to devise and test practical materials and methods of construction intended to achieve effective noise reduction at reasonable cost.

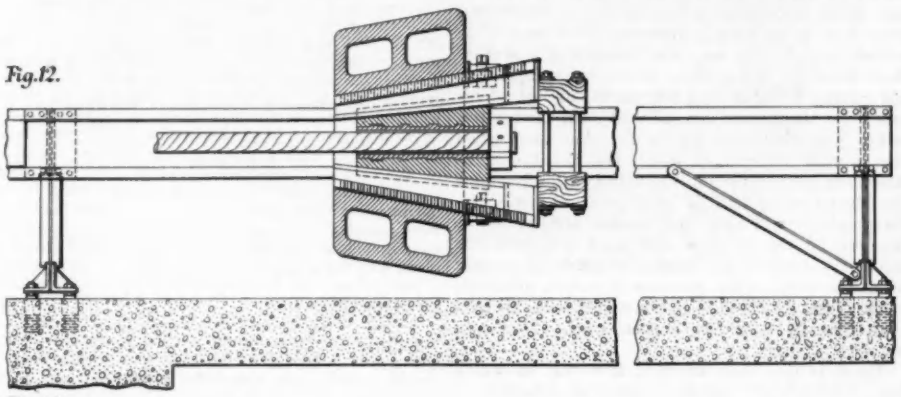
The general outcome is a technique of building

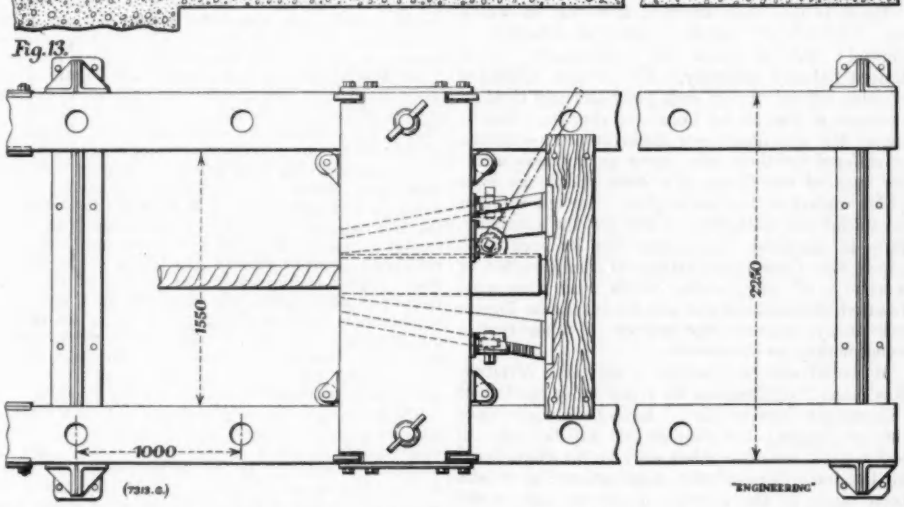
800-TON HYDRAULIC TESTING MACHINE.

MESSRS. ALFRED J. AMSLER AND COMPANY, SCHAFFHOUSE, SWITZERLAND.

(*For Description, see Opposite Page.*)







construction offering a degree of noise insulation not attainable by normal practice at the present time. It is described in this profusely-illustrated book, to which the science of acoustics and the practice of architecture have jointly contributed. In brief outline, the book deals successively with the origin of noise and the manner of its transmission throughout a building; with the properties of insulating materials and the methods of using them; and with the practical applications of the principle of discontinuous construction as a means of preventing noise transmission. The general recommendations are exemplified by detailed designs for rooms, houses, flats, hospitals and office buildings, while an appendix is devoted to the transmission of impact noise through concrete floors, with special reference to the "floating" floor as a solution for this troublesome problem. The text and the drawings are commendably clear, simple and practical, with the deliberate intention of presenting the information in a form which architects and builders can most readily appreciate and utilise, while the volume itself is substantially bound to resist the wear of constant reference. It can be cordially recommended, not only as a handbook for immediate use, but also as a guide and stimulus to individual designers upon whom the economy and success of noise abatement measures ultimately depend.

Non-Ferrous Foundry Practice. By J. LAING and R. T. ROLFE. London: Chapman and Hall, Limited. [Price 21*s.* net.]

TECHNICAL developments in the production and fabrication of non-ferrous metal alloys, more particularly perhaps those of the light metals, have been very rapid during the past few years, and it has been repeatedly stated in discussions at meetings of the metallurgical societies that careful classifications of the often widely-scattered literature regarding these materials should be undertaken periodically. The point which is usually stressed is the undesirability of needless duplication of research work, but the unwitting neglect of published data is disadvantageous in other ways, especially to the practical man. One of the aims of Messrs. J. Laing and R. T. Rolfe, both of whom have been actively engaged in the industry for many years, is to present to the foundryman a reasoned and concise survey of the properties and founding characteristics of the non-ferrous metal alloys as a whole. Recent work on the influence on alloys of impurities, furnace atmospheres, fluxes, and additions of small proportions of other metals, is dealt with and commented on, and such matters as inverse segregation and unsoundness in bronze and other castings are briefly explained. We note, however, that the subject of "pin-holing" in aluminium alloys as a result of the release from solution of absorbed gas when the metal cools, which has been discussed in several papers read in recent years before the Institute of Metals, is only just touched upon. The only remedy suggested is the somewhat rough and ready method (which, moreover, is sometimes difficult to accomplish satisfactorily), of pre-solidification, namely, allowing the metal to solidify in the melting pot and then rapidly re-melting for casting.

Generally speaking, however, those portions of the book dealing with foundry work proper are well thought out, the opening chapter on moulding sands being particularly informative. A good deal of space is devoted to moulding and casting technique in each of succeeding chapters dealing with the bronzes, brasses, high-tensile brasses and manganese bronze, aluminium bronze, copper-silicon alloys, copper-nickel, nickel-silver and other nickel-containing alloys, aluminium alloys and magnesium alloys. The positioning of gates and the arrangement of risers, chills, etc., are discussed with the aid of clear line diagrams. In some cases these may not meet with the entire approval of all practical men, but it has been our experience that foundrymen often have differences of opinion in matters of this kind and that their views are usually very decided, although the question may be only one of detail and not of principle. Possibly the authors have attempted to cover too wide a field, nevertheless, their book will constitute a worthy addition to the not particularly lengthy list of works on non-ferrous founding in general.

Generation and Transmission. By C. S. BECKETT. London: Blackie and Son, Limited. [Price 5*s.* net.]

THE object of Blackie's Electrical Engineering series, of which this book is one, is to provide a number of comparatively small volumes, each dealing with a particular section of the subject. The general standard is that of an engineering degree; and the work as a whole is intended to meet the needs both of the university and technical-college student and of the practising engineer. The present volume, as its title implies, deals with the interlinked subjects of generation and transmission. In the first section there are chapters on fuel and plant efficiency, boiler plant and auxiliaries, turbines and turbo-alternators, power-station layout and control, switchgear, and costs of supply. The second covers the choice of systems and voltage regulation, the construction of overhead lines, potential gradient and surges, the construction and testing of extra high-tension and protective gear.

This is all done in 116 pages, including illustrations and a certain amount of mathematics. The treatment is therefore distinctly concise. It is obvious that, to take one example, the whole of a work of this size could be devoted to the one subject of protective gear. Indeed, larger books on that subject have been written. Moreover, such is the searching nature of the degree examinations nowadays that more information on this matter than is provided by Mr. Beckett would certainly be required from the candidate.

The information given is accurate and the diagrams are clear, even if the selection is sometimes rather curious. Generally speaking, the second part should prove more useful than the first, though even so it cannot be considered complete in itself. There is scarcely a reference to other literature, current or historical. For some reason or other, though the names of de Laval and Ljungström are mentioned in the chapter on turbines, that of Parsons is omitted.

DEBTOR AND CREDITOR IN WAR-TIME.

NOT the least important of the measures adopted by the Government to ease the burden imposed by the war on the trading community is that which modifies the ordinary law which provides for the recovery of debts. Some account of the Acts of Parliament and Orders in Council by which special powers have been conferred on our Judges may be of interest to the engineering profession. During the last great war (which many of us hoped and expected would be the last great war) it was found necessary to give debtors a temporary relief from their obligations, if they could show inability to discharge them owing to circumstances arising out of the war. Accordingly, an Act was passed entitled "The Courts (Emergency Powers) Act," which prevented the enforcement of certain judgments without the leave of the court. In September, 1939, this Act was revived in a modified form, and it is now in force and is being daily applied in every court for the relief of defendants who are unable to pay their debts. It should be pointed out, however, that the debt or other obligation cannot be wholly discharged; the court can only postpone the day of payment. Normally, when judgment is given for a sum of money execution can issue at once and the defendant can be "sold up"; but in cases to which the Act applies execution can be stayed for a definite period, or until the war is over, or (but this is rare) indefinitely.

No relief can be given if the debt is due to the Crown or if it has arisen as a result of an action for (*inter alia*) damages for personal injuries, or libel or slander. But in any other case, as, for example, an action for the price of goods sold and delivered, for salary due, for rent, for interest due under a mortgage, for money lent, or for the possession of land or a house (the tenant having made default in the payment of rent), execution may be stayed if the defendant is able to show that his inability to pay is due to circumstances arising as a result of the war. Again, no landlord can distrain for rent, nor can a mortgagee foreclose without the leave of the court. This is all subject to the proviso that the debt or other liability was incurred before the war. The Act does not apply to post-war obligations.

What usually happens is this: the debt or other obligation having been proved or admitted, the court gives leave to the plaintiff to issue execution, subject to this—that the right to execute shall be stayed so long as the debtor complies with certain conditions. Thus, suppose there is an admitted debt of 100*l*. Judgment may be given for that sum, and execution may be stayed so long as the defendant pays (say) 10*l*. a month. Again, suppose a man is sued for rent in arrear say two quarters. Normally, he should have paid that rent on the due dates. But in the exercise of its powers the court may decree that he shall pay these arrears at a much lower rate per annum, and may discourage the landlord from suing for any further rent until all the arrears have been paid off.

It is condition precedent to relief that the defendant is able to prove that his inability to pay is due to the war. Where, for example, it appears that the debtor was hopelessly insolvent before September 3, 1939, it cannot be said that his inability to pay now is due to the war. On the other hand, if he can show that his business came to a sudden end as a result of the war, the case is one in which relief will be granted. There was one case in which a man enjoyed an income which ran into five figures at the outbreak of war. It was suddenly reduced to 600*l*. a year, with the result that he was wholly unable to pay his many debts. He was given a measure of relief. It is needless to point out that there are countless intermediate cases, each of which has to be considered on its own merits.

The Act had not been long in operation before this question arose: When considering the terms upon which relief is to be granted, when a debtor is sued by one of his creditors, must the court take his other liabilities into account? A man's total indebtedness to several creditors may amount to 1,000*l*. Suppose one of them has brought an action and recovered judgment for 100*l*., is this creditor to be preferred to the others? The Court of Appeal having laid it down that some regard is to be had to the other creditors, an amending Act was passed embodying the same principle and giving power to the court to summon the other creditors before it in order to hear their views. But this does not mean that the available assets of the debtor will be distributed rateably—as in the Bankruptcy Court: one creditor alone may be seriously pressing his claim.

The Emergency Powers Act and the various rules and regulations made thereunder are applied in practice with extreme simplicity and in a manner which is freed as far as possible from all technicality. When a creditor serves his writ in an action to recover a debt for which judgment cannot be enforced without leave, he is bound, at the same time, to give notice of this fact to his debtor, who may then intimate that he intends to apply for relief. The creditor then brings the matter before the court and it is heard—not in open court—but before a Master sitting in chambers.

Nor need the layman fear to attend before the Master in order to put his case himself. He will be best advised, of course, to consult a solicitor and allow him to do what is necessary, but even if he attend in person he may rest assured of a sympathetic hearing. Thus, when he comes unprepared—not having brought an affidavit in support of his case—the Master will generally adjourn the matter, telling him what he ought to do. And even when the case is not one in which the Court can, in strictness, give any relief, the debtor will often hear the Master suggest to the creditor's solicitor something which will ease the burden sought to be imposed on the debtor. Nor need a debtor fear publicity—because the matter is heard in private or, at the worst, in the presence of certain solicitor's clerks, each of whom is so concerned with his own case that he does not bother much about any other!

There is one class of case, however, in which the "defendant" must employ a solicitor or counsel; this is where the "defendant" is a limited liability company. No director, secretary or other official of any such body has any right of audience at the Royal Courts of Justice. This is one of the advantages—or disadvantages—enjoyed or suffered by those who carry on business under the ægis of the Company's Acts. And the logic which underlies the rule is plain: no one director or official has authority to act for the company. But—to manifest once again the leniency with which the Courts are acting—if the director or secretary of, say, John Smith and Company, Limited, does attend and ask for relief, the Master will always adjourn the matter in order that a solicitor may be instructed.

It would not be possible to say with certainty how many "applications for relief under the Courts (Emergency Powers) Acts" have been made since the war began; but they do not fall far short of 500 a week, and this refers only to the High Court in London; innumerable applications have also been made in the District Registries and in the County Courts during the same period. Nor is the effect of the Act to be measured only by the number of cases in which it is invoked. The knowledge that his debtor is entitled to ask for postponement of payment or to pay by instalments often induces the creditor to give time for payment.

THE DISTRIBUTION OF SMALL TOOLS.—A new company, Messrs. Tool Distributors, Limited, 17, Redcliff-street, Bristol, 1, has been formed for the purpose of pooling small tool resources. It is the intention of the new company to acquire, by purchase or by other means, new and second-hand small tools of every description. These tools will be available, on hire, for periods of one week and upwards on a weekly rental basis, the charge made being in proportion to the original cost of the tool. The company also proposes to introduce a scheme for booking tools in advance for a definite period so as to ensure that tools required at a certain stage of production will be available at the right moment. The firm has at its disposal a works where the inspection and re-conditioning of all tools returned from hire will be carried out.

THE ORCUTT HYDRAULIC GEAR-TOOTH GRINDER.

ONE of the problems associated with the expansion of munitions production due to the war is that of assuring an adequate supply of machine tools, and many firms who have hitherto specialised in other classes of work are now engaged in the production of such tools. In these cases, the quickest results are naturally secured by undertaking the manufacture of a machine already on the market, since the whole of the experience of the original manufacturers is then available for the guidance of the firm taking up the product. A typical illustration of this practice is afforded by the Orcutt hydraulic gear-tooth grinder. Although this tool has been on the market for a number of years, it has recently been improved in a number of respects, and is now being manufactured by both the original makers, Messrs. The Gear Grinding Company, Limited, and Messrs. Sunbeam Commercial Vehicles, Limited.

The latest model of the Orcutt gear grinder is illustrated in Figs. 1 to 9, on the opposite page and on pages 203 and 204. As many of our readers will be aware, the formed-wheel method of grinding is employed on this machine, that is to say, the gear blank is held stationary during a cut, and the space is formed by the traverse of a grinding wheel of the exact contour of the finished space. There is thus no generating mechanism associated with the actual grinding operation, and although such a mechanism is necessary in connection with the wheel-truing device, it is only in operation for about 5 per cent. of the grinding time, so that wear on this mechanism is correspondingly reduced. Another advantage of the formed-wheel method of grinding is that grinding takes place on the whole working surface of the wheel, instead of on the edge only, as in gear-generating machines, so that the wear is distributed over a much greater surface. A point of almost equal importance is that on the formed-wheel grinder, the continuously-moving parts of the machine are such as can be found on almost any first-class machine tool, and that the most important elements, such as the work spindle, the indexing mechanism, and the grinding-wheel spindle, are independent of each other, enabling repairs and replacements to be greatly simplified.

As will be clear from Fig. 1, the grinding wheel is mounted on a cross spindle carried in a reciprocating slide, and is driven by multiple-Vee belting from a motor mounted on the same slide. The spindle is mounted on two Timken taper-roller precision bearings as near the grinding wheel as possible, and one precision roller bearing at the pulley end. The depth of cut is regulated by raising and lowering the work, and the only additional mechanism mounted on the wheel slide is a root-truing device for the wheel, which will be referred to later. The work spindle is carried in a heavy vertical slide with hand adjustment, and this slide also carries the indexing mechanism. This mechanism is carried on the back of the slide, that is, the face opposite to the wheel blank, and is therefore readily accessible from the end of the machine. The remaining essential element, the truing device for the wheel flanks, is located in the portion of the main frame partially masking the wheel in Fig. 1, and as all adjustments, such as changing the forms, are carried out from the front of the machine, the mechanism is also very accessible. The controls, with the exception of the stroke dogs, are all grouped on the front of the machine in convenient positions for the operator.

The mechanism for reciprocating the main horizontal slide is generally similar to that employed on other hydraulically-operated grinders, and hardly calls for particular comment. In the earlier models, the motor driving the main oil pump, which also drove the suds pump, was mounted on an extension of the main frame at the end remote from the work head, but although still located in approximately the same position, the oil-pump motor is now enclosed within the main frame, and is controlled by the two push buttons on the right of the panel, visible in Fig. 1. The suds pump is now driven by a separate motor, controlled by the left-hand buttons on the panel. Only one speed is employed for the grinding slide, starting and stopping being effected by the control lever visible on the panel below the suds-pump control buttons. If desired, however, lower speeds for the slide can be obtained by partial opening of the control valve. Normally, the slide operates between two dogs on the rear side of the machine, these dogs being set to the width of the gear to be ground. The dogs operate a valve controlling the oil supply to the ram cylinder in the usual way. When it is desired to true the grinding wheel, it is necessary to over-run the dog remote from the wheel head to enable the wheel to enter the truing device, and when the trip lever, visible in Fig. 1 on the panel below the main-motor buttons, is moved to the right, the appropriate dog is rendered inoperative and the slide comes back against a positive stop to its truing position. If a small lever on the truing device is first moved, the additional travel of

THE ORCUTT HYDRAULIC GEAR-TOOTH GRINDER.

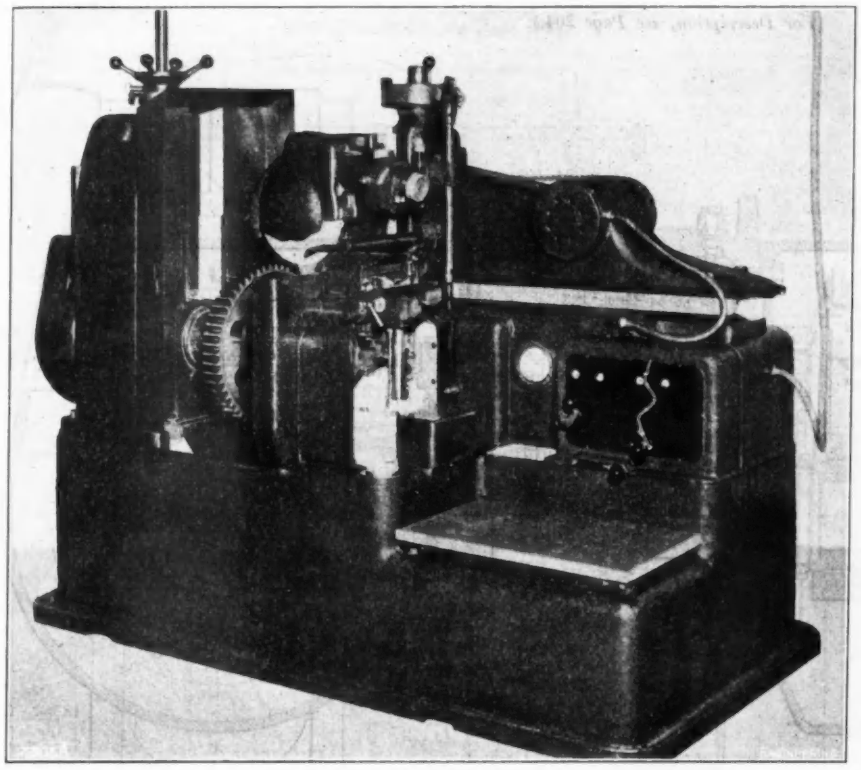


FIG. 1 OPERATING SIDE OF MACHINE.

the slide to the right brings a cam into operation which starts the automatic trimmer. The trimmer can be started independently by the movement of another lever provided for the purpose.

One of the most important and interesting features of the machine is the indexing mechanism, illustrated in Figs. 2 to 7, page 206. This mechanism has recently been modified, the figures showing the latest design. The index plate *a*, Figs. 2 and 3, is mounted directly on the work spindle by means of a cone at each end, as shown in Fig. 2. This has been found to be the best way of maintaining concentric mounting of the plate relative to the work spindle, as any wear in the holes does not affect the accuracy. The vertical index shaft is shown at *b*, Fig. 3, and it will be observed that it is provided with a crank at the top with adjustable throw to give the correct movement for different index plates. A cross-section through the crank-pin is given in Fig. 4, the adjusting slide being shown in this figure in end section. The crank pin is connected through a universal joint by the rod *c*, Fig. 3, to the indexing arm *d*, the connection on the arm being made through another universal joint, as shown in Fig. 5. Mounted on the arm *d* is the feed pawl *e*, which registers with the teeth on the index plate, as shown in Fig. 2. It will now be clear that a half revolution of the index shaft *b* will advance the index plate one tooth. The motion is slightly in excess of the travel required, in the usual way, and as the index shaft makes the second half revolution to return the arm to its initial position, the index pawl *f*, which has fallen in behind the tooth on the forward stroke of the plate, comes into contact with the registered face on the tooth of the index plate. The index pawl *f* is mounted on a ball bearing, as shown in Fig. 6, and is provided with a separate hardened-steel nose to register with the tooth. Its downward travel is limited by the adjustable stop *g*. As the spindle, index plate and wheel blank possess considerable inertia, a damping device is provided on the spindle, taking the form of a lightly-applied brake. The brake drum is shown at *h* in Figs. 2 and 3, and it will be seen from the latter figure that it is embraced by two brake shoes *j*, linked together at the bottom. At the top, the shoes are held together by a spring *k*. The spindle *l* is screwed through the right-hand shoe, and its end is in contact with the left-hand shoe. Plates *m* are riveted to the latter shoe, and these plates are bridged by a circular block *n* sliding on a rod *p*. This rod is anchored to the casing at the left-hand end, as shown in Figs. 3 and 7, and the block *n* is in contact with a sliding collar *q* backed by a spring, the brake shoes being free to float against the spring pressure. It will be noticed from the figures that all the important elements in the link mechanism for the indexing gear are provided with precision ball bearings to reduce wear to a minimum. The surface on the locating side of the index teeth is ground on a special dividing engine to give an accumulated error not exceeding 0·0002 in. on a 16-in. diameter index plate, this being the maximum error allowed. Provision is made for moving the spindle relative to the index plate when it is desired to centre the gears with the grinding wheel. For this purpose, an adjusting block, marked *r* in Fig. 2, is mounted on the end of the spindle, a thumb-screw being provided in each arm of the adjusting block with the inner ends of the screws making contact with a pin screwed into the plate. The upper portion of the adjusting block is split to enable it to be readily removed to change the index plate.

Before passing on to the trimming devices, it should be stated that it is impossible to operate the indexing mechanism while the grinding stroke is in operation, or vice versa. The main control lever on the panel simply controls the oil supply from the pump to a timing valve. The latter valve has four positions, two controlling the ram cylinder, and two the indexing cylinder. The timing valve is rotated by a hydraulic motor, supplied with oil from the main circuit, and its position is controlled by the main trip lever operated by the slide.

As already mentioned, two devices are provided for trimming the wheel, the flanks and crest being trimmed separately. The flank trimming is effected by means of the pantograph mechanism illustrated in Fig. 9, page 207. As previously stated, the trimming mechanism can be set in operation automatically after the main slide has been brought back clear of the work, or can be started by hand. The lever for bringing the automatic control into operation is shown at *t'*, Fig. 9, and the hand-control lever is shown at *b'*. The lever *t'*, in effect, constitutes a safety device. The plunger *a'*, with which the cam on the slide makes contact, terminates in a fork carrying the pawl *v'*, and so long as the lever *t'* is in the locked position, this pawl is clear of the slot *c'* in the pluger *d'*. In these circumstances, accidental contact of the cam against the plunger *a'* merely compresses the spring shown. On release of the lever *t'*, however, the pawl falls into the slot *c'*, and movement of the plunger *a'* then also moves the plunger *d'*. The right-hand end of this plunger is provided with a projection engaging with a slot in a disc, this disc being on a shaft coupled by bevel gearing to a rotary valve controlling the oil supply to the mechanism for feeding the wheel on to the diamonds. When the plunger *d'* is moved to the left, therefore, this mechanism comes into operation. At the same time, the movement of the plunger opens the passage *e'* in the oil system for the trimmer cylinder *f'*, setting the trimmer piston *g'* in motion. This piston is connected to a head carrying a pantograph at the fulcrum points *h' h'*, the pantograph being formed by the levers *i i'* and *j' j'*, and the links *k' k'* and *l' l'*. The links *k' k'* terminate in pegs *m' m'*, which are held in contact with the forms *n' n'* by the spring *o'*. The spindles carrying the two diamonds are at *p' p'*, the diamonds being at the far ends of the spindles and not visible in the figure. As the head makes its upward stroke, the pawl *q'* attached to it rotates the ratchet *r'*, and this ratchet is again rotated on the return stroke of the piston by the pawl *s'*, also attached to the head. This ratchet is connected to a rotary valve, and after it has made a complete revolution, the oil circuits are closed by the return of the plunger *d'* and the whole mechanism is again brought to rest. It will be observed that the hand control lever *b'* is connected to an arm engaging with a slot in the plunger *d'*, so that the movement of this lever has the same effect as the depression of the plunger *a'*. Dealing now with the feed mechanism, already referred to, the rotary valve controls the oil supply to a cylinder in the machine base. The piston of this cylinder operates a vertical push rod, which, when the table is in the trimming position, registers with the rod, visible in Fig. 1, projecting from the bottom of a tubular casing mounted on the side of the slide. The upper rod operates a pawl and ratchet mechanism, the ratchet wheel being mounted on the top of the feed spindle in the casing visible at the top of the slide.

The reduction of movement from the form pegs to the diamond points is 6 to 1. The diamond radius is set by a gauge, and any wear on the diamonds themselves is taken up by changing the form pegs. The pantographs will operate for two years or more with the machine in daily use, and it is recommended that they should be replaced entirely when wear takes place, rather than that they should be repaired. The forms are made from mild-steel plate, and are finish-milled from a master template three times larger than the form. A pair is made for every gear, with intermediate forms between each number of teeth to compensate for diamond wear when the desired shape is not reproduced. They are quickly changed and can be supplied at a low cost for any involute tooth. A vertical adjustment is provided on the slides to which the forms are attached, as shown in Fig. 9. This adjustment enables both diamonds to be set at exactly the same height.

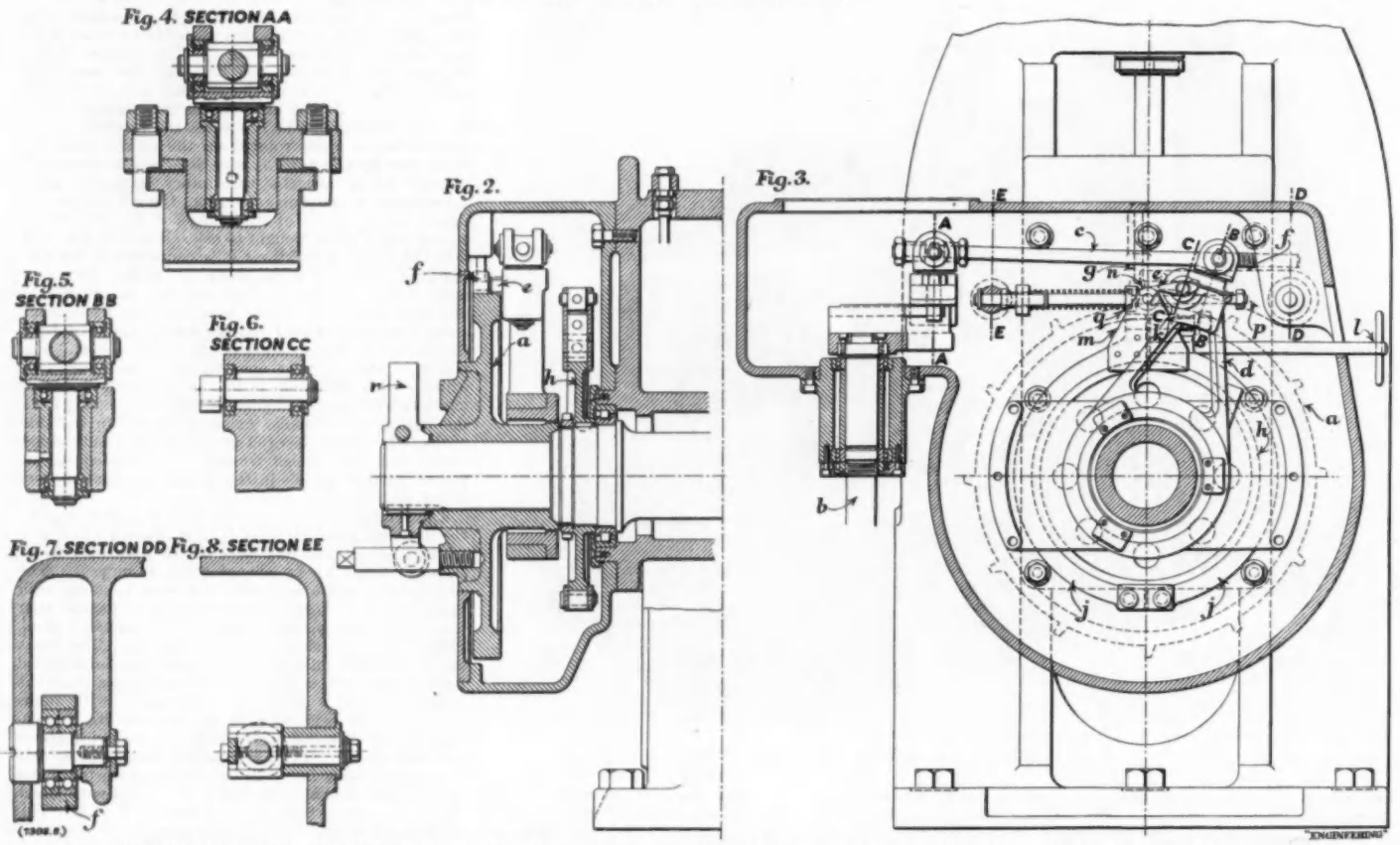
The root trimmer, which trues the periphery of the grinding wheel, is designed to give a single radius joining the flanks of the teeth. This form is peculiar to the Orcutt grinder, and tests carried out by the National Physical Laboratory show that gears formed in this way have a remarkable endurance as compared with those having the crown form of root fillet, in spite of the greater tooth length. The trimmer can be seen in Fig. 1 above the wheel. The trimmer is hand-operated, but provision is made for automatically feeding down the diamond, as the wheel is reduced in diameter. Adjusting screws are provided for centralising the root radius when necessary. The trimmer consists essentially of a cranked spindle carrying the diamond, and rotated by means of the hand knob visible on the back of the casing in Fig. 1. If required, the base of the tooth space can be formed with two radii and a flat instead of a single radius, provision being made for the additional side movement of the spindle to produce this form.

FACTORIES AND THE BLACK-OUT.—With the approach of the winter, the question of factory black-out becomes of increasing importance. Factory managers who are again faced with the question of obscuring lighting are reminded, therefore, that a pamphlet entitled "War-Time Lighting Restrictions for Industrial and Commercial Premises," can be obtained from H.M. Stationery Office, York House, Kingsway, London, W.C.2. This pamphlet gives complete information on the subject; its price is 2*d.*, or 3*d.*, including postage. The Ministry of Home Security states that, although the pamphlet was issued shortly before the war, it is still completely up to date.

CONTROL OF POTASH.—The Minister of Supply has made an Order, entitled the Control of Caustic Potash and Carbonate of Potash (No. 1) Order, 1940, under which purchases by consumers of caustic potash and carbonate of potash may be made only under licence. Quantities not exceeding one half-ton a month are, however, exempt. It is the intention only to license purchases in which the use of these materials is essential, and where substitution is impossible. Application forms for licences can be obtained from the Secretary, Raw Materials Department, Ministry of Supply, Shell-Mex House, Strand, London, W.C.2. Envelopes should be marked "Caustic Potash" or "Carbonate of Potash."

THE ORCUTT HYDRAULIC GEAR-TOOTH GRINDER.

(*For Description, see Page* 204.)



THE AVIEMORE ACCIDENT ON THE L.M.S. RAILWAY.

(*Concluded from page* 198.)

Conclusion.—Although the material of the drawbar appears to have been sound, its capacity for resisting shock was, no doubt, adversely affected by its crystalline structure, and the failure was due either to a rebound when the train was brought to a stand at Slochd home signal, or to a snatch when it was being restarted from that point. As the enginemen were not aware that anything untoward had happened until afterwards, and the evidence of guard Moyes is not in itself sufficiently conclusive, it is impossible to deduce from them when the breakaway actually occurred. Nevertheless, certain timings, which appear to be comparatively accurate, assist in arriving at a decision on that point. I am of the opinion that the failure occurred when the train was brought to a stand at the home signal, and was the result of a slight rebound due to the use of the brake. Having regard for the steep rising gradient (1 in 70) it should have been unnecessary to use the brake to stop the train at this point, but driver MacDonald found that he had to do so on this occasion, probably on account of the fact that, owing to the curve and cutting, his view of the home signal was curtailed by the engine in front. For that reason it is to be regretted that the train was being controlled from the second engine, an irregularity for which both he and driver McAdie must be held jointly responsible.

For the serious consequences of the breakaway, I hold Moyes, the guard of the train, and Ferguson, the signalman at Slochd, responsible. The former was a poor witness and it is difficult to determine with any certainty what action he took when the train came to a stand at the home signal. Although his brake van was not fitted with rail-sanding gear, he had sufficient brake power at his disposal to hold the rear portion of the train while it was stationary, or even moving slowly, but once it began to gather speed, he would have no chance of controlling it. It is not unlikely that he lost valuable moments before realising in the darkness the direction in which his van was moving. I cannot help feeling that had the train been in charge of a guard with more extensive experience of the severe gradients on the Highland section, the runaway would have been avoided. Moyes had been employed as a goods guard in the Edinburgh district, where the gradients are considerably easier, for 17 years and was transferred to Inverness only four months prior to the accident. There is no question that he was competent to be in charge of the train, and once he realised that the rear portion was travelling in the wrong direction, he appears to have taken all reasonable steps to check it before he wisely decided to jump. Then he evidently lost his head, as he followed the runaway train on foot as far as Carrbridge. Had he proceeded in the opposite direction, towards Slochd, he might have been the means of conveying an earlier intimation to signalman Ferguson that the rear part of the train had run away.

Ferguson, in the absence of any information on this point, made a grave error in assuming that the missing portion was stationary near his home signal. If he had taken appropriate action immediately he realised, at 8.26 p.m., that the train had arrived incomplete, valuable time would have been saved, which might have enabled signalman Calder at Carrbridge to derail the runaway train at the entrance to the station, and the staff at Aviemore to hold the 2.45 p.m. train, which did not leave till 8.30 p.m., and adopt other precautionary measures. Having been employed as a signalman at Slochd for 11 years, he should have been alive to the possibilities of the severe gradients in that neighbourhood. The signalmen at Carrbridge and Aviemore, however, acted promptly, and it is unfortunate that their efforts were not more successful.

Recommendation.—The question of material for wagon draw-gear generally has already received considerable attention, as it has been realised that wrought iron does not fulfil all the requirements of modern traffic conditions. I have referred to the decision to supersede wrought iron by steel, and as the change-over appears to be taking place as expeditiously as practical circumstances permit, I have nothing further to add. The process must, however, take time, and even when completed will not entirely eliminate the possibility of trains parting. Consideration should be given, therefore, to the provision of suitable means to reduce to a minimum the effects of a breakaway. Much can be done in this direction by an alert and skilful guard, and it is important that he should have at his disposal as much brake power as possible. I think that the use of brake vans fitted with sanding gear should be extended, and on certain hilly sections of the line it should be made obligatory. Certain factors may render a guard almost helpless from the start, and in localities where exceptional conditions exist, provision should be made for dealing with a runaway train in an emergency. Such conditions unquestionably exist between Carrbridge and Slochd, and if this were a double line, catch points would certainly be provided; with single track this question is not so simple, but I consider that means should be devised to prevent a train running back uncontrolled into the section towards Aviemore. At the present time, the only possibility of doing so is by reversing the points at the north end of the loop while the runaway vehicles are actually passing over them, but this is hardly practicable for various reasons, and should not be regarded as a reliable safeguard. A number of alternative suggestions were considered at the time of my Inquiry and have been further dealt with by correspondence. As a result, the Company have suggested the provision of electrically-operated catch points, sufficiently far north of Carrbridge station to ensure that any derailment effected by them would not involve risk to the users of the public roadway immediately north of the station. Control of these points would be provided in the booking office, and they would be proved closed and bolted for up trains, and trailable for down trains, by withdrawal of the respective section token.

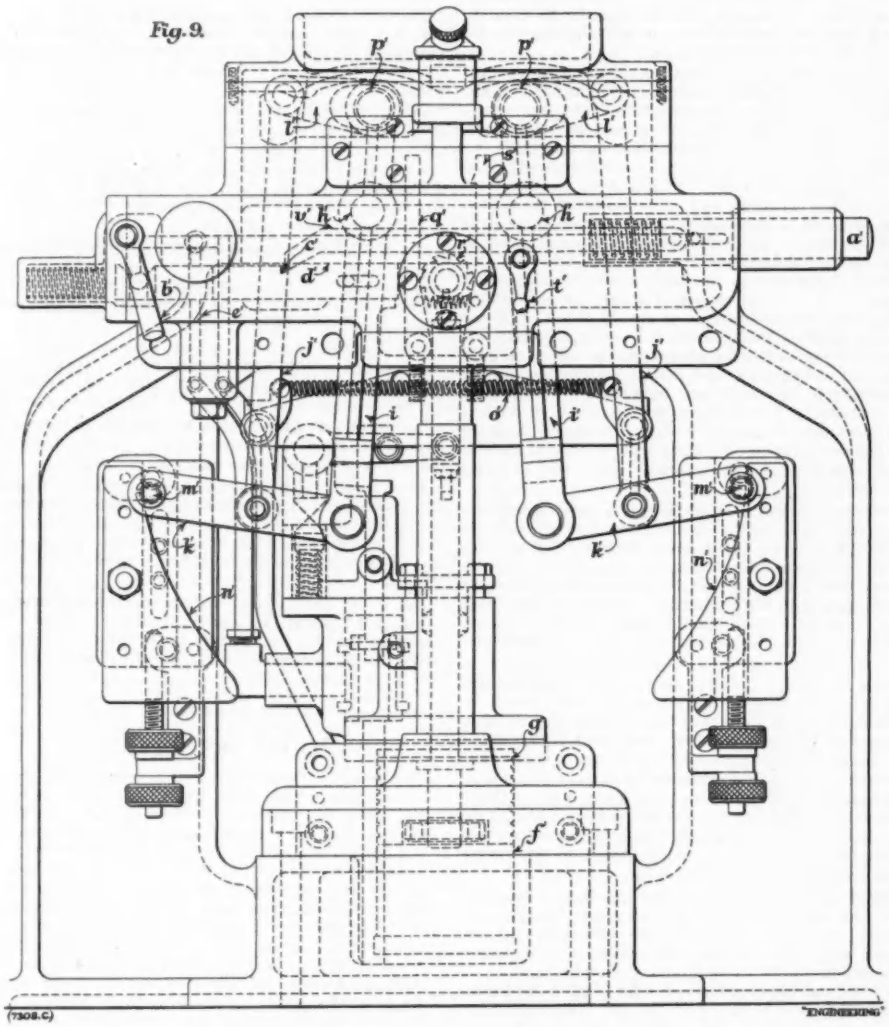
I see no objection in principle to this proposal, so long as satisfactory arrangements can be made whereby it becomes impossible for a token to be obtained at Slochd for an up train unless the catchpoints are set and bolted for through running, and are held in this position until the train has arrived, and the token has been restored to the instrument at Carrbridge. Similarly, means should be provided whereby a token cannot be withdrawn for a down train from the instrument at Carrbridge unless the catchpoints are set to derail a runaway, and are free to be trailed; they must be maintained in this position until the down train has reached Slochd and the token which it has been carrying has been restored to the instrument there. The equipment should provide also for the release of the starting signals by the token.

If these requirements can be suitably complied with, electrically-operated catchpoints as proposed appear to fulfil all that is necessary at this particular place, and their provision is recommended, subject to due consideration of the controlling and safeguarding arrangements. Such equipment has a further advantage that it is independent of the station layout, and might be installed elsewhere on single lines, where similar risks exist. This possibility is receiving the attention of the Company.

THE ORCUTT HYDRAULIC GEAR-TOOTH GRINDER.

(*For Description, see Page* 204).

Fig. 9.



THE FUTURE OF BRITISH CIVIL AVIATION.*

(*Continued from page* 200.)

Education and Training.—However carefully we may plan the organisation of civil aviation, success in the end must always depend on the people engaged in it. A proper appreciation of this is essential for the ultimate success of British civil aviation. Technical progress depends upon the initiative, intelligence, energy, knowledge, skill and resource of the designers and research workers. Education can impart knowledge and skill, but the others are personal qualities. Aviation must ensure that it gets its fair proportion of men with these qualities. It can only do this by providing careers attractive intellectually and pecuniarily. This has been realised on the official side, where the conditions of employment and prospects of advancement have steadily improved. Each year there is a steady flow from the universities of mathematicians, engineers and physicists into the Government service to work on the technical and scientific problems of aviation. This tendency needs further encouragement by the development of better prospects in the industry for university-trained men, by the continual improvement of careers on the official side, and by a more widespread introduction of aeronautics into university curricula.

At present, in the universities, aeronautics tend to be rather a side line. It is possible in the University of London to take aeronautics as one of the subjects of the degree examination in engineering, and appropriate courses are available at Northampton Engineering and Queen Mary Colleges. There is a post-graduate course at the Imperial College of Science and Technology leading to the Diploma of that College. One of the most encouraging signs recently has been the decision of the University of London to institute a degree of Bachelor of Science (Aeronautics). The teaching of aeronautics, nevertheless, is still localised. No facilities exist in the majority of universities and university colleges. This is illustrated by the fact that there are only three professors of aeronautics, at the Imperial College, Cambridge University, and Hull University College. There are Readerships in London University (Queen Mary College) and Glasgow University. It is not suggested that every university should have its aeronautical staff and laboratory. It is desirable, however, that every college teaching engineering should illustrate the fundamental principles by appeal to aeronautical examples as well as to those of what are generally termed civil, mechanical and electrical engineering; that applied mathematicians should be led from hydrodynamics to aerodynamics; and that physicists should be introduced early to the physical phenomena of airflow and the principles of aircraft instruments.

I think it is true to say we are moving towards this desirable state of affairs, but the movement is so far spasmodic and uncoordinated. There is need for a coherent scheme of aeronautical education which would embrace the improvement of conditions of employment, relate the demand for and supply of talent, insinuate aeronautical ideas into general instruction, provide for advanced teaching, and elevate professional status. This Society, by stiffening the standards of its Associate Fellowship examinations, by championing the idea of the engineering degree in aeronautics, by its lectures, by its encouragement of the student, has played, already, a great part in aeronautical education. There is no body better qualified to bring about the plan I have briefly sketched.

So far, I have considered recruitment from the universities. They are likely to supply material for making designers and research workers, who cannot, in these days, do their work without academic training. The builders of aeroplanes need a different background. The man with the university degree may be well suited to a post in works management, but we shall not look to the university as the main source of supply. There has grown up a number of institutions, often connected with the apprenticeship schemes of firms in the industry, which, while providing elementary theoretical training, concentrate rather upon the more practical aspects of aeronautics. The men destined for the works posts naturally gravitate to these institutions, and their importance in the educational scheme cannot be overestimated. Here, the atmosphere is purely aeronautical and, whereas I have advocated a little more aeronautics in the general engineering training of the university, it may well be that the tendency should be to introduce a little more generality into the engineering training of these practical schools. The usual aims in these schools are the Associate Fellowship examination of this Society and the Air Ministry's Ground-Engineers' Certificates, and the Society and the Air Ministry have, in consequence, a great responsibility, for the technical standards of these colleges are inevitably related to the standards of these examinations.

We may expect for some time to come that the recruiting ground for airline pilots will be the Royal Air Force. The R.A.F. training does not, however, immediately fit a man for air transport duties. He must, before piloting others "for hire or reward," become appropriately certificated, and his certification refers by name to the aeroplane types he is permitted to fly. Besides his *ab initio* examination, the addition to his certificate of each successive type follows only upon his passing of an examination on the type. Airline pilots have in recent years developed strong professional instincts, evidenced by the formation of the Guild of Air Line Pilots and Navigators, and the British Air Line Pilots' Association. These bodies, in collaboration with the Air Ministry and the Air Registration Board, were engaged in increasing the already high standard demanded of pilots. The changes were to a considerable extent consequent upon the increase in complexity of the aeroplane. Despite all safety measures, things will sometimes go wrong, and the pilot must be able to diagnose and deal with any trouble that may arise. He has to-day to be a mixture of pilot, navigator and engineer. The achievement of the necessary knowledge is, in the case of the companies forming the British Overseas Airways Corporation, in the hands of experienced training staff. The development and extension of the system would be expected to proceed naturally.

Finance.—Of the avenues I have ventured into in this journey, the most depressing is the financial one. Civil aviation, I regard as a necessity of commerce and as an instrument of prestige. Sometimes it is possible to develop a commercial necessity by purely commercial means and simultaneously achieve national prestige. This happened in the development of the mercantile marine. I do not think that anyone any longer believes that development on this basis is possible for British civil aviation. Civil aviation must be dealt with as an essential Empire service. Its value and success are not measured by the profits and losses calculated in its own counting-houses. Its importance lies in the great commodity it provides—speed. This speed brings more men together more often and enables them to transmit more quickly to one another their ideas, their orders, and their more valuable goods. The effect of this on Imperial trade cannot now be calculated, and probably never will be. It may be argued that if commerce wanted this thing, commerce would pay for it. But such an argument ignores the make-up of the modern world. The industrial revolution is over; the commercial success of aviation has become less and less related to private pioneering enterprise and more and more the responsibility of the State.

I have already given some idea of the things for which money is required. I will not venture to say how these things will be procured and how much they will cost. All that is certain is that a courageous act of reorganisation is required and that for several years to come substantial help from public funds will be essential. The United States were faced with a similar task only a little while ago. When the Civil Aeronautics Authority assumed office, it found the American air transport industry in a state described in the House Committee in charge of the new legislation as "chaotic." Half of the private capital which had been invested in the industry had been irretrievably lost. More than half of the domestic airlines carrying mail disclosed operating deficits for the year ending June 30, 1938. The lesson we have to learn is that the Federal Government did not hesitate to take drastic steps to reorganise the government of civil aviation and that steps, mainly directed towards co-ordination and unification of control, appear successful now.

(*To be continued.*)

* Summary of the Wilbur Wright Memorial Lecture of the Royal Aeronautical Society, delivered on May 30 by Dr. H. Roxbee Cox.

THE PROPERTIES AND APPLICATIONS OF WITHERITE.

ALTHOUGH naturally-occurring barium sulphate, which is known by various names, including barytes, heavy spar, and cawk, is widely distributed throughout the world, deposits of barium carbonate, or witherite, as it is termed, are much less common. Indeed, it is stated in a handbook issued jointly by The Holmside and South Moor Collieries, Limited, and The Owners of Settlingstones Mines, Limited, that witherite is found in economic quantities only in the northern part of England and that the mines producing it supply the world demands for the mineral. The material derives its name from that of Dr. W. Withering, a Birmingham physician and amateur geologist, who, in 1784, when examining samples taken from an old lead mine at Alston Moor, on the borders of Cumberland and Northumberland, first recognised the mineral to be chemically distinct from barytes. Witherite usually occurs as a white, yellowish-white or light-grey mineral. It has a hardness of from 3 to 3·75 on Moh's Scale, a specific gravity of between 4·29 and 4·35, and is dimorphous, the crystals being either hexagonal or orthorhombic. The mineral is quite brittle, and on a fractured surface the lustre is vitreous, with, however, a tendency to a resinous appearance. At the Northumberland mine, near Fourstones, operated by The Owners of Settlingstones Mines, Limited, and at the Durham mine, owned by The Holmside and South Moor Collieries, Limited, South Moor, Stanley, County Durham, modern ore-dressing and washing plants are installed, where the extracted witherite is washed and graded. The mineral is marketed in the form of clean lumps, nuts, peas and fines, the $BaCO_3$ content ranging from 95 per cent. in the clean lumps to 90 per cent. in the fines.

As it is a carbonate, witherite possesses advantages over the mineral sulphate, barytes, which is practically the only other industrial source of barium. Witherite is readily decomposed by the mineral acids and by many organic acids, yielding the corresponding salts which, in many cases, are soluble in water and can be crystallised. On the other hand, the use of barytes as the basic material for the preparation of other barium products involves an initial furnacing operation to convert the insoluble sulphate into the soluble sulphide. Large quantities of witherite are used annually in the preparation of precipitated barium sulphate or "permanent white" (*blanc fixe*), which is employed in the paper industry for the manufacture of highly-glazed coated papers. It is also used in the printing-ink and colour industries, in the manufacture of paints and as a filler in the rubber, linoleum and other industries. Barium chloride is employed as a mordant in the dyeing and printing of textiles, while barium nitrate is a constituent of explosives and is also used in the ceramic industry for the production of glazes.

Among other engineering applications of witherite is the softening of water for boiler feed. It is particularly useful when scale-forming and corrosive waters are encountered. Thus, sodium and calcium sulphates are converted into the carbonates of these metals, with the precipitation of insoluble barium sulphate. Ground witherite, mixed with wood charcoal, usually in the proportion of 40 per cent. of the former and 60 per cent. of the latter, has been used for many years as an "energiser" for carburising compounds in the case-hardening industry. Considerable proportions of barium oxide, in some cases nearly 50 per cent. by weight, enter into the composition of crown and flint optical glasses used for the production of lenses. Experiments by various authorities, consisting in the addition of finely-divided barium carbonate to cement to increase its resistance to the action of sulphate-containing waters, have been made recently. Encouraging results have already been obtained, and investigations are still proceeding. It is stated that the barium carbonate has no effect on the crushing strength or other mechanical properties of the finished concrete, but that it causes an inert insoluble skin to form on the surface.

FLAX GROWING IN NEW ZEALAND.—The Government of New Zealand, at the request of the Government of the United Kingdom, is to institute the planting of flax over an area of 15,000 acres. This will produce, it is hoped, 8,000 tons of linen flax annually.

LABELLING OF PARCELS SENT BY TRAIN.—The railway companies have made an application to the Railway Rates Tribunal for an alteration to the regulation for the labelling of merchandise when carried by goods trains. At present, the regulation provides that, subject to certain conditions, a specified proportion only of a number sent to the same consignee need be labelled. The railway companies now request that every parcel be labelled when sent by goods train. Complete wagon loads would not be affected.

BRITISH STANDARD SPECIFICATIONS.

THE following specifications of engineering interest have been issued by the British Standards Institution. Copies are obtainable from the Publications Department of the Institution, 28, Victoria-street, London, S.W.1, and, unless otherwise stated, the price is 2*s.* net, or 2*s.* 3*d.* including postage.

Ventilator Light Traps.—A specification in the air-raid precautions series, dealing with light-locks at the entrances of buildings (BS/ARP No. 15) was issued some time ago. Many factories and office buildings, however, have to be occupied during the black-out hours in warm weather, and their ventilation has given rise to many problems. It has been necessary to obstruct the windows and other openings in such a manner as to provide a light trap without interfering with ventilation, and with a view to giving guidance in this matter, a new specification, BS/ARP No. 31, entitled "Ventilation for Buildings in Conditions of Black-Out," has been prepared under the aegis of the Joint Lighting Committee of the Ministry of Home Security and the Illuminating Engineering Society. It describes the principles of design, the effect of light traps on ventilation, and suitable materials for the construction of ventilator light traps. Numerous illustrations of typical light traps for use in various circumstances are given. Although primarily designed for factory buildings, the light traps described are also applicable to domestic buildings. [Price 8*d.*, including postage.]

Pressure Creosoting of Timber.—Prepared in response to a request from the Institution of Municipal and County Engineers, specification No. 913-1940, dealing with the pressure creosoting of timber, has recently been issued. The methods of incising the timber and of stacking it in the creosoting cylinder are described, and accounts given of the full-cell, or Bethell, process and of the empty-cell, or Rueping, process of creosoting.

Carbon-Steel Castings.—A revised specification for carbon-steel castings for ships, marine-engine and general-engineering purposes has just been issued. It is designated No. 592-1940, and supersedes specifications Nos. 30-1907, 592-1935, and 5028-1924. Three grades of castings are covered by the specification, namely, those having ultimate tensile strength values between 28 tons and 35 tons per square inch, between 35 tons and 40 tons per square inch, and a non-test grade. The latter are castings which comply with the specification except that sulphur and phosphorous determinations and tensile and bend tests are not required.

Black Bolts and Nuts.—A war-emergency specification, No. 916-1940, dealing with small hexagon and square black bolts and nuts, has been prepared and issued under the authority of the Ministry of Supply. It is additional to the well known specification No. 28 for bolts and nuts, and provides for black bolts having heads and nuts smaller than the full Whitworth sizes. The specification has been prepared in consultation with the manufacturers and it is estimated that it will effect a saving of some 60,000 tons of steel per annum. The dimensions of the heads and nuts are those of the next smaller nominal size in the Whitworth series, and permit the use of existing spanners. The specification makes provision for both the B.S. Whitworth and the B.S. fine threads.

Electrical Wiring Conduit and Fittings.—A fourth revision of specification No. 31, which deals with steel conduits and fittings for electrical wiring, has recently been issued. The revision of the third edition of the specification, which had been published in April, 1933, was undertaken principally with the object of clarifying the position of the cover-fixing lugs relative to the spout outlets in small circular boxes. Furthermore, the table giving the dimensions of entry bushes has also been slightly modified.

Laboratory Porcelain.—A new specification, No. 914-1940, is concerned with tests for laboratory porcelain. The tests relate to appearance, shape and weight; to porosity of body and imperfections in glaze (dye test); to resistance to heat and sudden change of temperature; to constancy of weight and resistance of glaze to high temperatures; and to resistance of glaze to acid and alkali. The tests should be helpful both to manufacturers and to users. The porcelain industry in this country is developing rapidly and it is hoped that the publication of this specification will assist in the further improvement of the quality of British laboratory porcelain ware.

THE ASSOCIATION OF ENGINEERS, INDIA.—The recently issued annual report, for 1939, of the Association of Engineers, 2, Royal Exchange-place, Calcutta, shows that 22 new members were elected during the year, but that the Association lost two members by death and one by resignation. The membership at the end of 1938 had totalled 494.

PERSONAL.

PROFESSOR F. HORTON, F.R.S., has been re-elected Vice-Chancellor, and PROFESSOR D. HUGHES PARRY, Deputy Vice-Chancellor, of the University of London for the year 1940-41.

The Ph.D. degree in the Faculty of Engineering, University of London, has been conferred upon MR. E. W. THOMAS, a student of Battersea Polytechnic, and upon MR. A. C. WALSHAW, a student of Northampton Polytechnic.

MR. H. H. ADDISCOTT, F.S.I., is retiring from the firm of Messrs. T. M. Deacon, Son and Addiscott, chartered surveyors, Cecil Chambers, 76, Strand, London, W.C.2. The practice is being continued at the same address by the remaining partners, MR. S. M. DEACON, F.S.I., and MR. R. M. KNIGHT, P.A.S.I., under the style of Messrs. T. M. Deacon, Son and Knight.

MR. E. W. GOULD retired from the position of manager of the Great Western Railway Docks, Plymouth, on September 2. He has been succeeded by MR. ROBERT DIXON, hitherto head of the commercial section, Chief Docks Manager's office.

MR. THOMAS WATSON, works manager of Messrs. Stewarts and Lloyds, Limited, Clyde Tube Works, Coatbridge, Lanarkshire, has retired after many years of service. He has been succeeded by MR. J. CHALMERS.

CAPTAIN E. C. ERIC SMITH, M.C., has been elected a director of Messrs. John Brown and Company, Limited, Clydebank Shipyard, near Glasgow.

MR. EDGAR P. BROWN, deputy chairman of the Caledon Shipbuilding and Engineering Company, Limited, Caledon Shipyard, Dundee, has succeeded his uncle, the late MR. PETER SAUNDERS BROWN, as chairman of the firm. An obituary notice of Mr. P. S. Brown appeared on page 194, *ante*.

MR. J. A. MCCULLOCH has resigned his position as secretary to Messrs. R. and W. Hawthorn, Leslie and Company, Limited, St. Peter's Works, Newcastle-upon-Tyne, owing to ill-health. He is to be succeeded by MR. R. J. ALLAN.

BOOKS RECEIVED.

United States National Bureau of Standards. Building Materials and Structures. Report BMS. 46. *Structural Properties of "Scot-Bilt" Prefabricated Sheet-Steel Constructions for Walls, Floors and Roofs, Sponsored by The Globe-Wernicke Company.* By H. L. WHITTEMORE, A. H. STANG and V. B. PHELAN. [Price 10 cents.] Report BMS 48. *Structural Properties of "Precision-Built" Frame Wall and Partition Constructions, Sponsored by the Homasote Company.* By H. L. WHITTEMORE and A. H. STANG, with the collaboration of G. E. HECK. [Price 10 cents.] Report BMS 49. *Metallic Roofing for Low-Cost House Construction.* By L. J. WALDRON. [Price 10 cents.] Washington: Superintendent of Documents.

Highway Research, 1920-1940. Prepared by the Committee on Research Activities of the American Association of State Highway Officials and the Highway Research Board. Edited by A. R. RANKIN. Washington, D.C.: American Association of State Highway Officials; Highway Research Board.

United States Bureau of Mines. Technical Paper No. 603. *Phenomena in the Ignition of Firedamp by Explosives.* Part I. *Particles from the Detonation.* By S. L. GERHARD and W. J. HUFF. [Price 10 cents.] Technical Paper No. 604. *Carbonizing Properties and Petrographic Composition of Pocahontas No. 3-Bed Coal from Buckeye No. 3 Mine, Wyoming County, W.Va., and of Pocahontas No. 4-Bed Coal from No. 4 Mine, Raleigh County, W.Va.* By A. C. FIELDNER and others. [Price 15 cents.] Technical Paper No. 609. *Bentonite: Its Properties, Mining, Preparation and Utilization.* By C. W. DAVIS and H. C. VACHER. Revised by J. E. CONLEY. [Price 15 cents.] Technical Paper No. 613. *Developments in Coal Research and Technology in* 1937 *and* 1938. By A. C. FIELDNER. [Price 10 cents.] Washington: Superintendent of Documents.

Vibration in Machinery. An Introduction to General Principles. By DR. W. A. TUPLIN. London: Sir Isaac Pitman and Sons, Ltd. [Price 7*s.* 6*d.* net.]

United States Geological Survey. Bulletin No. 912. *Spirit Leveling in Utah,* 1897 *to* 1938. By J. G. STAACK. [Price 30 cents.] Bulletin No. 916-C. *Transit Traverse in Missouri.* Part 3. *East-Central Missouri,* 1903 *to* 1937. By J. G. STAACK. [Price 20 cents.] Washington: Superintendent of Documents.

United States Coast and Geodetic Survey. Special Publication No. 219. *Triangulation in New Mexico.* (1927 *Datum.*) By F. L. CULLEY. [Price 40 cents.] Special Publication No. 220. *Triangulation in South Carolina.* (1927 *Datum.*) Part 1. *First- and Second-Order Triangulation in the Northwestern Part of the State.* By H. P. KAUFMAN. [Price 20 cents.] Washington: Superintendent of Documents.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—As would be expected, the bulk of the production at the Scottish steelworks is intended for Government departments or for firms engaged on work of national importance. Licences are, however, being granted for material for export where this can be spared. With the shipyards all fully occupied, a very large tonnage of plates and sections is being consumed. Engineers, boiler-makers, power-plant makers, and practically all concerns using steel material are exceedingly busy, and despite the current high output, the steel-makers are occasionally finding it difficult to keep all their buyers supplied. The makers of steel sheets are exceptionally busy. Prices are unchanged, and are as follows:—Boiler plates, 15*l.* per ton; ship plates, 14*l.* 3*s.* per ton; sections, 13*l.* 13*s.* per ton; medium plates (rolled in sheet mills), ½ in. and thicker, 18*l.* 7*s.* 6*d.* per ton; mild-steel black sheets, No. 21-24 gauge, close annealed, 19*l.* 7*s.* 6*d.* per ton; galvanised sheets, plain, No. 21-24 gauge, 23*l.* 2*s.* 6*d.* per ton, and corrugated, No. 24 gauge, 22*l.* 12*s.* 6*d.* per ton.

Malleable-Iron Trade.—Conditions in the malleable-iron trade of the West of Scotland have not changed. Although order books are well filled, some makers are rather short of suitable malleable scrap at the moment. This condition, however, is tending to improve. The re-rollers of steel bars are as fully employed as possible, and are turning out a large tonnage. The supply of semi-manufactured material is ample for their requirements and the forward position is regarded as very satisfactory as good stocks are now held. The following are the current prices:—Crown bars, 15*l.* 2*s.* 6*d.* per ton; best iron, 15*l.* per ton; No. 3 bars, 13*l.* 7*s.* 6*d.* per ton; No. 4 bars, 13*l.* 12*s.* 6*d.* per ton; re-rolled steel bars, tested, 15*l.* 11*s.* 6*d.* per ton, and untested, 15*l.* 8*s.* 6*d.* per ton; angles and tees, 4 in. and under, tested, 15*l.* 1*s.* 6*d.* per ton, and untested, 14*l.* 18*s.* 6*d.* per ton, all for home delivery.

Scottish Pig-Iron Trade.—The Scottish pig-iron position is good and production is at a maximum. An improvement in the supplies of iron ore has been reported and the outlook is quite satisfactory; new shipments have been arriving and more are expected. The requirements of the steel makers are being well met, but the demand for foundry grades is poor.

AMERICAN COLLIERY INDUSTRY.—The average daily output of butuminous coal, in the United States, during the week ending August 10, was 1,425,000 tons, compared with 1,379,000 tons in the preceding week and 1,238,000 tons in the corresponding week of 1939.

PRODUCTION OF ASBESTOS IN CANADA.—Statistics issued by the Bureau of Mines of Quebec show that, during the first six months of the present year, 156,457 tons of asbestos were produced in the Province, as compared with 144,208 tons in the corresponding period of 1939.

BAUXITE IN ULSTER.—According to *The Chamber of Commerce Journal*, the Ministry of Supply is investigating the possibility of developing deposits of bauxite in Ulster. In several areas, especially in County Antrim, the deposits have been worked, but the amount available has never been ascertained.

INDIAN AIR-SURVEY OPERATIONS.—We learn from *Indian Engineering* that upwards of 83,000 sq. miles in India and Burma have been surveyed since the air-survey operations began in 1924. The surveys have been undertaken for the purpose of geological research and to provide data for town planning, harbour development, irrigation works and the development of power-transmission lines.

HIGH-VOLTAGE SERVICE TESTING WITH DIRECT-CURRENT: ADDENDUM.—We are asked to state that the report on High-Voltage Service Testing with Direct-Current, to which reference was made on page 175 of our issue of August 30, is generally available and can be obtained from the British Electrical and Allied Industries Research Association, 15, Savoy-street, London, W.C.2, at the price of 6*s.*, plus postage 6*d.*

TRANSMISSION OF SHIPPING DOCUMENTS TO PORTUGAL.—It is stated in *The Board of Trade Journal* that complaints have been received from importers in Portugal of delays in clearing goods shipped from the United Kingdom owing to the non-receipt of the shipping documents forwarded by another vessel. United Kingdom exporters are strongly advised to forward such documents by air mail to ensure their arrival in good time.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

General Situation.—There is little change in the general state of the iron and allied trades, but the few new features encourage the hope that conditions will enable an increasing tonnage to be released for usual requirements. As yet, however, general commercial business is restricted by the continued heavy demand for material for war-time needs. At the same time, the maintenance of the aggregate production at a high level, and the adherence to the control of distribution regulations, are covering urgent Government needs and gradually providing a moderate tonnage for other purposes. Export trade is on a better scale than was anticipated and promises to expand.

Cleveland Iron Trade.—The make of Cleveland pig is still light and irregular and there is no sign of a movement towards a material increase of output. The shortage of local iron, however, is causing little inconvenience as ample deliveries from other iron-producing centres are steadily coming to hand. Midland brands are extensively used in North-East Coast foundries and supplies of Scottish makes are obtainable for specific purposes. Merchants are handling only very moderate quantities of Cleveland pig, the fixed prices of which remain at 120*s.*, delivered within the Tees-side zone.

Hematite.—The heavy production of East Coast hematite is hardly adequate for current needs; there is but little saleable iron. As in the Cleveland pig department, second hands have command of little iron, the bulk of the large supply being absorbed by the requirements of producers' own consuming plants. Buyers have extensive contracts against which to draw and are pressing for full deliveries; they are also seeking to place new orders. The makers state that they are able to meet the actual needs of consumers, but an increase in the make appears to be necessary. Stabilised quotations remain at the equivalent of No. 1 grade of East Coast brands at 131*s.*, delivered to North of England customers.

Basic Iron.—The output of basic iron is sufficient for the heavy needs of local steelworks, but provides no tonnage for use elsewhere. The recognised market value of Tees-side basic iron remains at 113*s.*

Foreign Ore.—Imports of foreign ore are satisfactory and consumers' stocks are larger than has been the case for a considerable time.

Blast-Furnace Coke.—Durham blast-furnace coke is plentiful, but as sellers' order books are well filled and local users have made provision for their needs as far ahead as they care to commit themselves, transactions are few. Quotations are ruled by good medium qualities at 33*s.* 5*d.* at the ovens.

Manufactured Iron and Steel.—Re-rollers are receiving ample supplies of semi-finished iron and steel, and all the mills in operation are turning out heavy tonnages. The make of semies is well maintained and imports continue on a substantial scale. Sheet makers have sufficient work to execute to ensure the full activity of their plant for some months; manufacturers of all descriptions of constructional steel are extensively sold, and an unprecedented tonnage of shipbuilding requisites is being produced to meet the current demand. Soft steel billets are quoted 10*l.* 10*s.* to 10*l.* 15*s.*; hard billets, 11*l.* 17*s.* 6*d.*; joists and angles, 13*l.* 13*s.*; heavy plates, 14*l.* 3*s.*; and boiler plates, 15*l.* 0*s.* 6*d.*

Scrap.—There is still some shortage of wrought-iron and heavy-steel scrap, but deliveries of most other kinds have increased sufficiently to enable stocks to be considerably replenished.

AMERICAN MINING CONGRESS.—The 7th annual American metal-mining convention and exhibition will take place at Colorado Springs, U.S.A., from September 16 to 20.

MERCHANDISE PASSING THROUGH PANAMA CANAL.—During June, 695,141 tons of merchandise were conveyed through the Panama Canal from the Atlantic to the Pacific and 1,093,642 tons from the Pacific to the Atlantic.

MODIFICATION OF ALUMINIUM-SILICON ALLOYS.—The British Aluminium Company, Limited, Raven Hotel, Castle-street, Shrewsbury, Shropshire, has issued a pamphlet entitled "The Modification of Aluminium-Silicon Alloys." Modification by means of metallic sodium additions is recommended as the most convenient, although the "salts" method in which a mixture of salts—with sodium fluoride predominating—is added to the melt, is also described. The pamphlet deals very thoroughly with the effect of modification on the mechanical properties of aluminium-silicon alloys and describes the best method of making the additions and of controlling and pouring the melt.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Speaking of Sheffield's contribution to the war effort, the Master Cutler, Mr. Ashley S. Ward, said: "The efforts put forth have far exceeded expectations, and the variety, quality, and volume, given in detail, would be impressive. This result is, in a measure due to the foresight and enterprise of its industrialists, in the early days of re-armament, who were able to meet the urgent drive for munitions when the crucial moment came." Despite armament requirements, Sheffield continues to do good trade in ordinary commercial products. Several orders have been placed with the heavy machinery and engineering branches during the past few weeks. Though the volume of business is principally on home account, export trade shows an improvement. Many of the large firms are anxious to extend their overseas connections, and are taking steps to develop trade with the South American countries. Among the lines in demand are railway rolling stock, crushing and grinding machinery, shipbuilding steel, and forgings and castings. Steelworks' and ironworks' machinery and related equipment continues in strong request on home account, while a better call is reported from South Africa. Tool and implement-making works are operating at full capacity. Not only is the inland demand substantial, but there is an increasing call from abroad. The demand for special steels has been main-crushing and grinding machinery, shipbuilding steel, and branches show little change; producers are having some difficulty in coping with the rush of orders.

South Yorkshire Coal Trade.—Business is brisk in all types of coal. Industrial concerns are consuming record tonnages, and are taking in larger supplies for stocking purposes. Steam coal is a particularly active line and smalls and slacks are in demand by electric power stations. The house coal market is more active. Business in cokes of all types has been maintained.

ROAD TRANSPORT DIPLOMA.—Evening courses for the Road Transport Diploma of the Royal Society of Arts are to be re-opened as usual this month in London and many other centres.

MINERAL PRODUCTION IN QUEBEC.—During the first seven months of the present year, 186,799 tons of asbestos, 577,839 oz. of gold, and 713,516 oz. of silver were produced in the Province of Quebec. During the corresponding period of 1939, the production totalled 172,879 tons of asbestos, 559,245 oz. of gold and 635,118 oz. of silver.

REGISTRATION OF NEW MOTOR VEHICLES.—Statistics show that 11,565 new road motor vehicles were registered in July, compared with 40,829 in July, 1939. It may be recalled that the Emergency Powers Defence Order, under which the Minister of Transport prohibited the acquisition of new unregistered motor vehicles except with a licence from the Ministry, came into force on July 20.

THE FRIANT DAM, CALIFORNIA.—The placing of concrete has recently been commenced at Friant Dam, which is being built across the San Joaquin River to provide irrigation water for five counties in California, U.S.A. A total quantity of 2,200,000 cub. yd. of concrete will be required for the dam, which is to be of the gravity type, 3,340 ft. long and 325 ft. high. The capacity of the reservoir created will be 520,000 acre-ft.

GRAND COULEE DAM.—In a recent issue of *Engineering News-Record* it is stated that a portion of the Grand Coulee Dam, 700 ft. in length, has been completed sufficiently to allow motor cars to run over the 30-ft. wide roadway provided. The dam, which is being built across the Columbia River by the United States Bureau of Reclamation, is expected to be completed in 1942, when it will be possible for motor cars to run the whole distance from abutment to abutment, namely, 4,300 ft. The maximum height of the dam above the bed rock of the river is 550 ft.

CONTROL OF TIMBER.—The Control of Timber (No. 17) Order has been made by the Minister of Supply and came into force on August 31. The Order introduces a new schedule of the maximum prices for home-grown timber hitherto set out in the Schedules to the No. 1 and No. 12 Orders. In general, there is no change in prices, but in a few cases adjustments are made in the prices of home-grown mining timber. In particular, the differential prices for Scottish mining timber delivered to mines in England are abolished and a transport subsidy is to be paid on long railway hauls in the United Kingdom and on sea freight from Ireland and Scotland. The new Order contains a slightly amended definition of timber, which provides that flooring blocks and flooring strips, however prepared, are to be regarded as timber for the purposes of the Order.

GRIPPING HEADS FOR 800-TON HYDRAULIC TESTING MACHINE.

CONSTRUCTED BY MESSRS. ALFRED J. AMSLER AND COMPANY, SCHAFFHOUSE, SWITZERLAND.

(*For Description see Page* 201.)

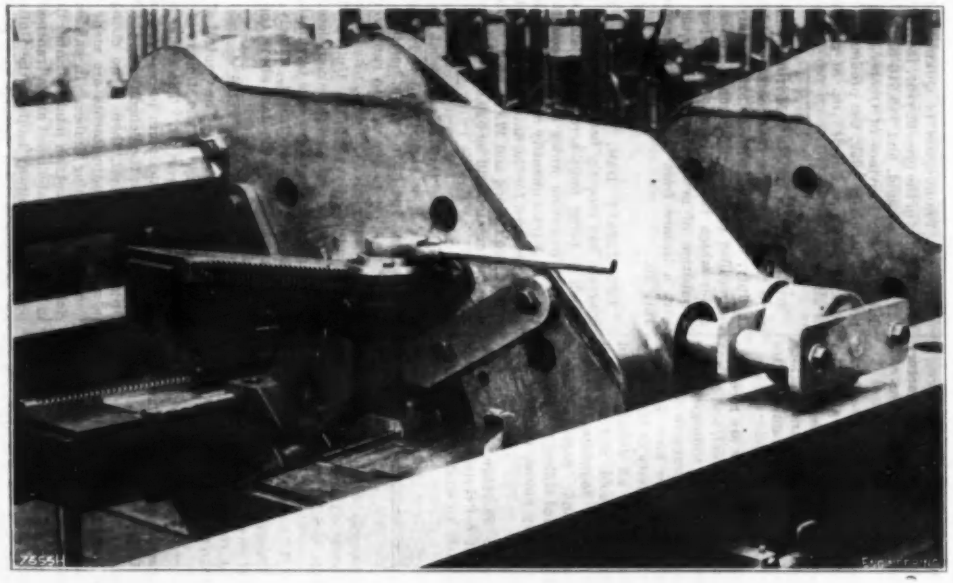


FIG. 14. PINION AND RATCHET GEAR FOR REMOVING GRIPPING WEDGES.

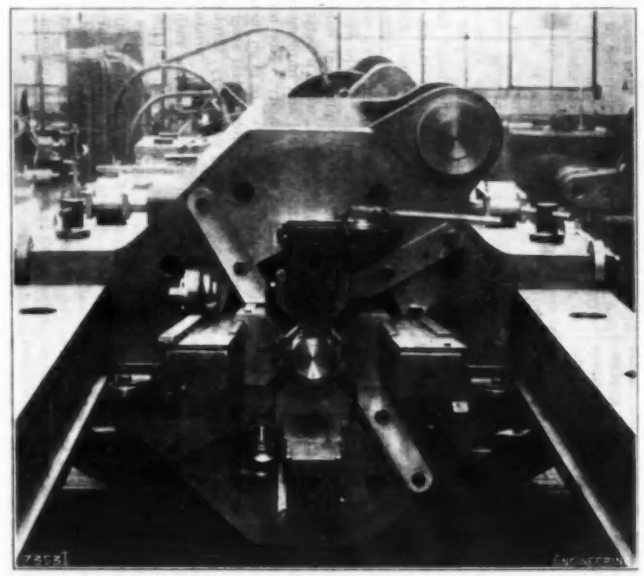


FIG. 15. GRIPS FOR CYLINDRICAL SPECIMENS.

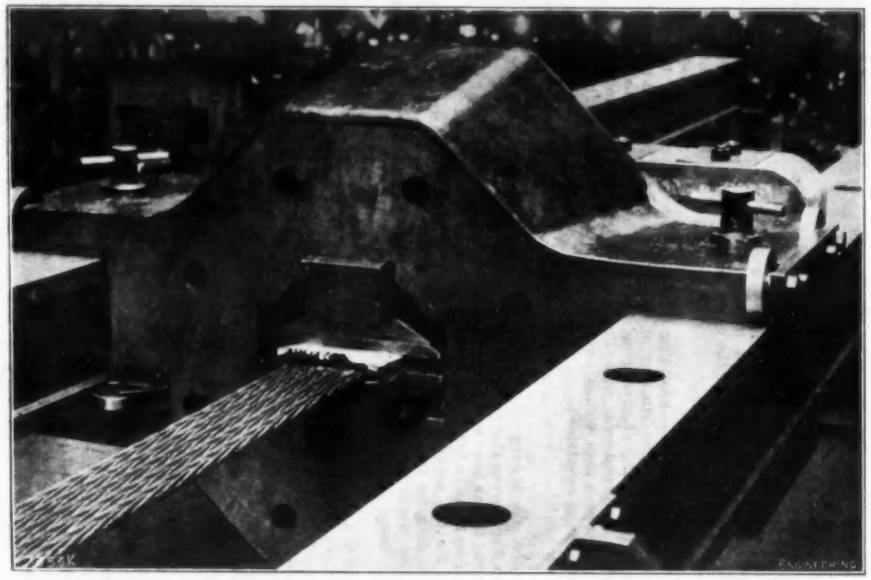


FIG. 16. GRIPS FOR FLAT WIRE ROPES.

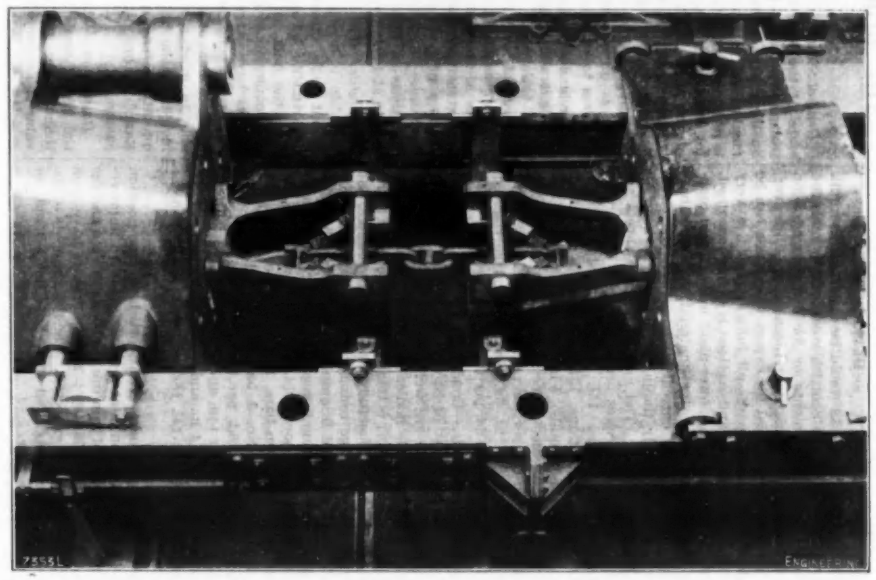


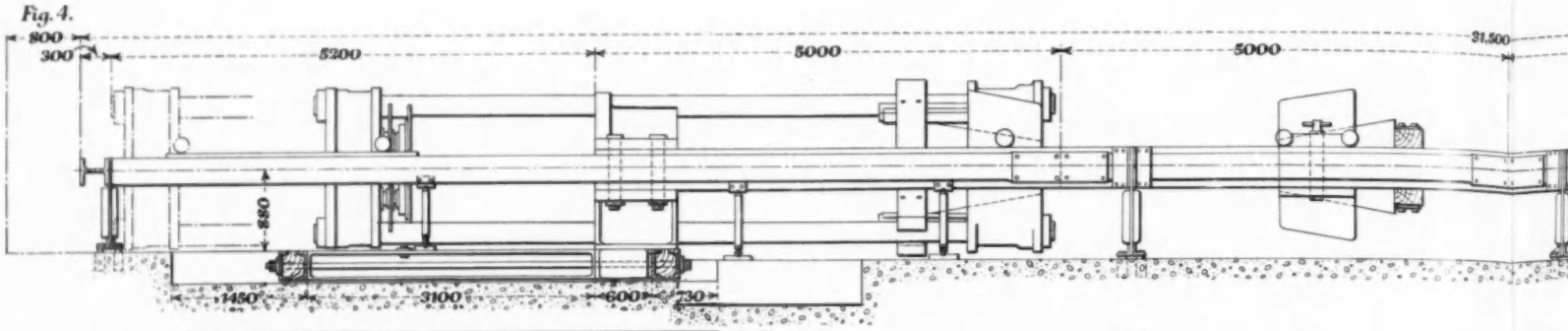
FIG. 17. GRIPS FOR TESTING CHAINS.

800-TON HORIZONTAL HYDRAULIC TENSILE

CONSTRUCTED BY MESSRS. ALFRED J. AMSLER AND CO

(For Description, se

Fig. 4.



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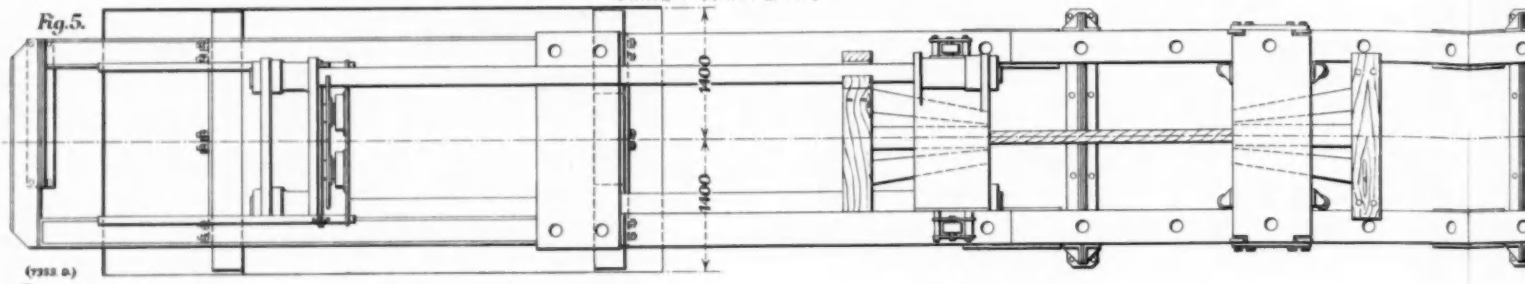


Fig. 6.

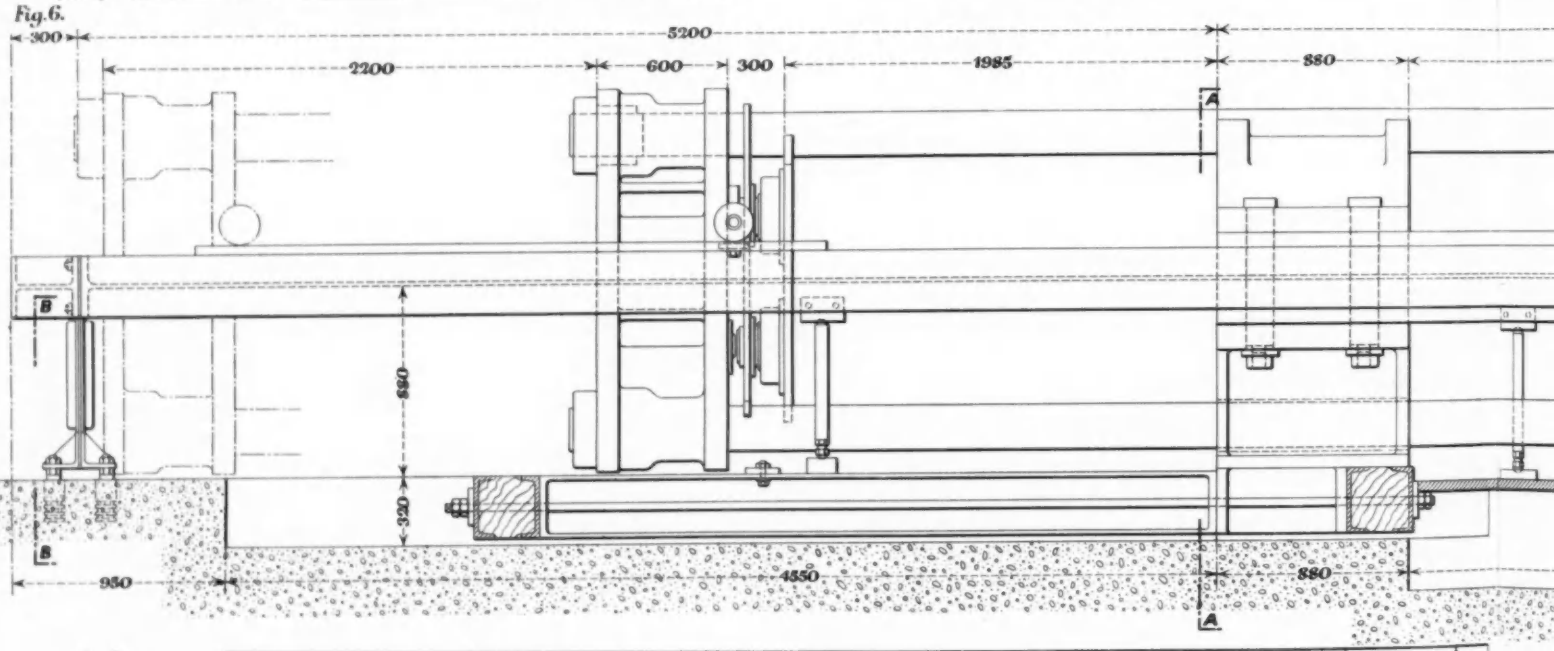
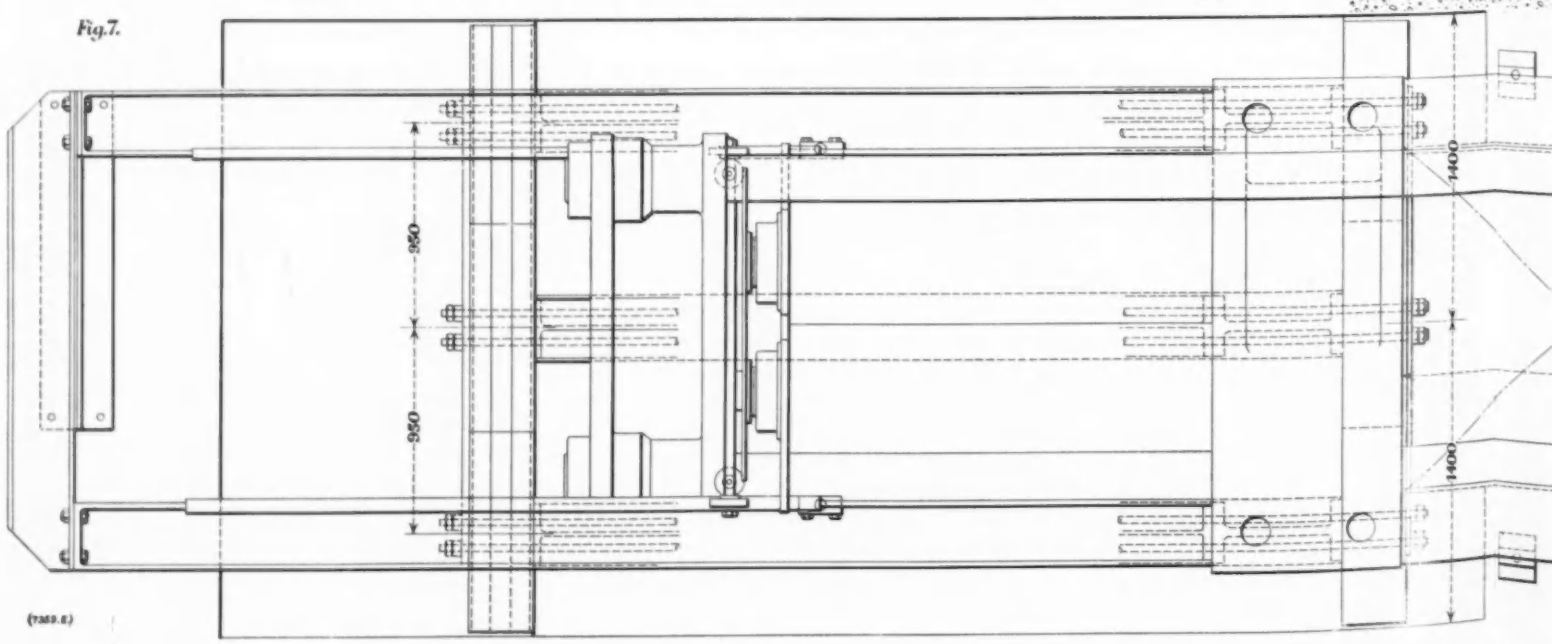


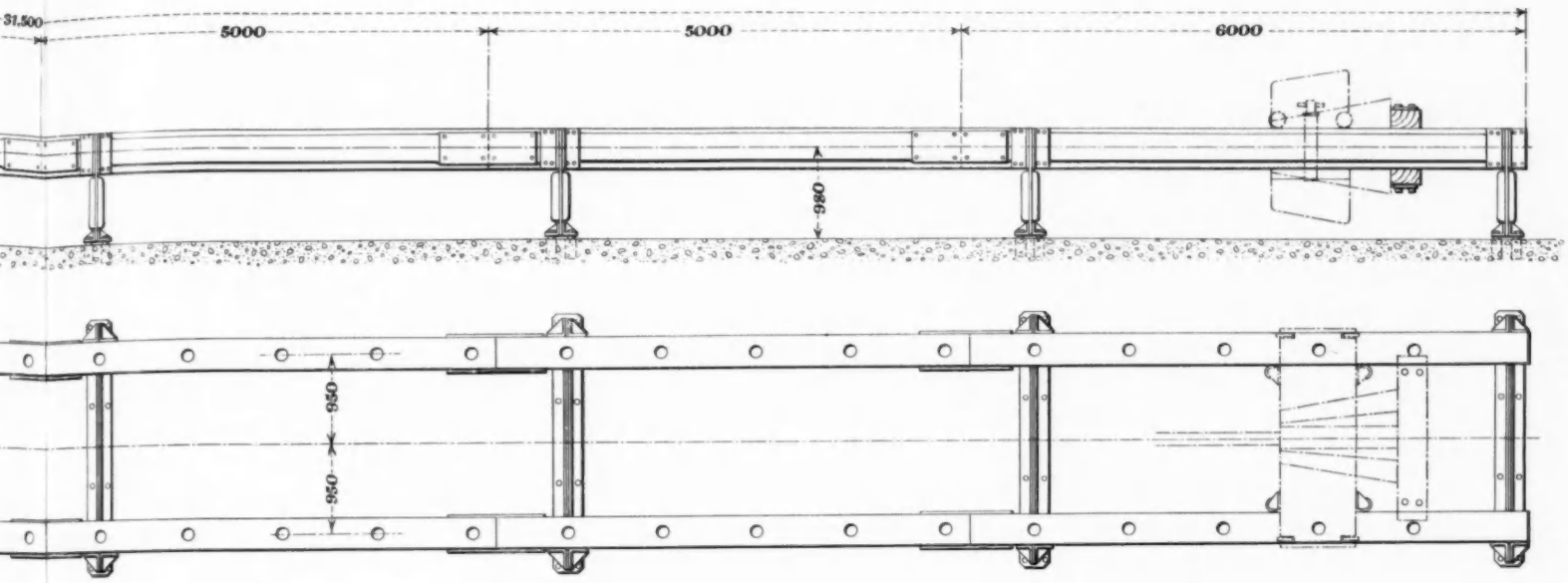
Fig. 7.



NSILE AND COMPRESSION TESTING MACHINE.

ER AND COMPANY, ENGINEERS, SCHAFFHOUSE, SWITZERLAND.

(For Description, see Page 201.)



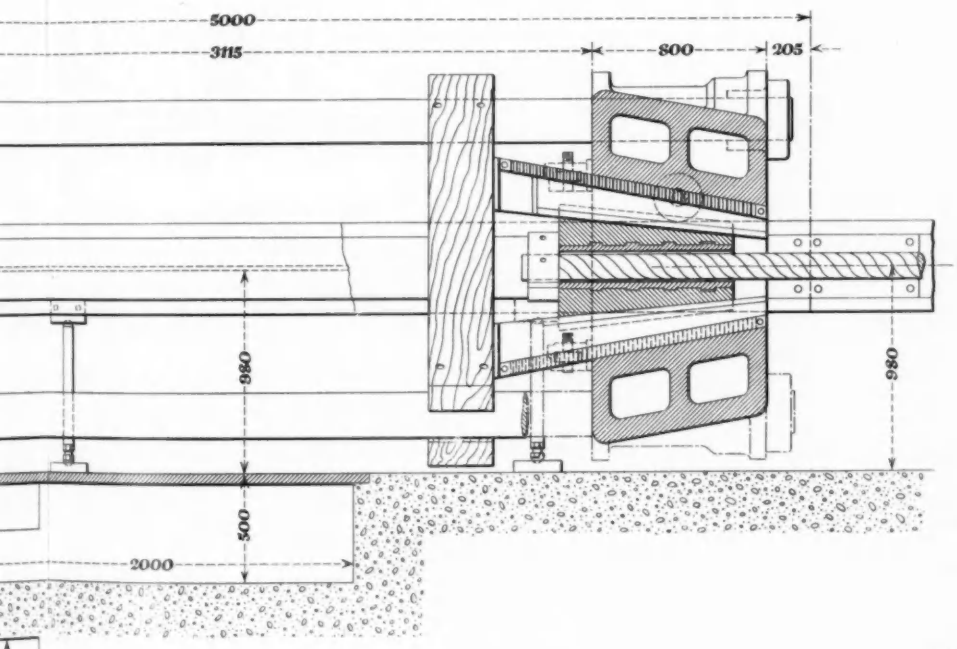
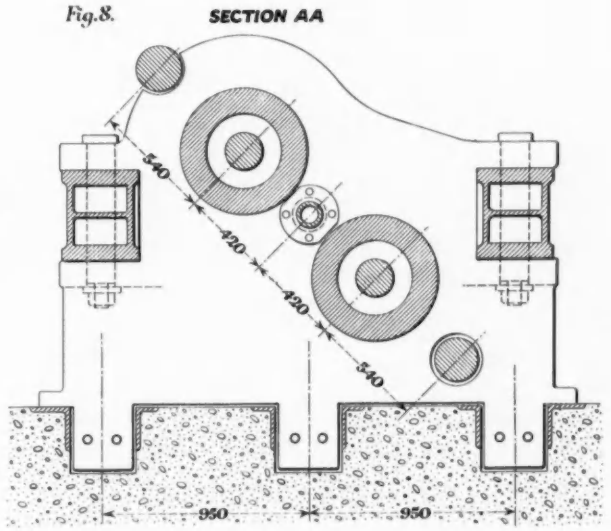


Fig. 8. SECTION AA



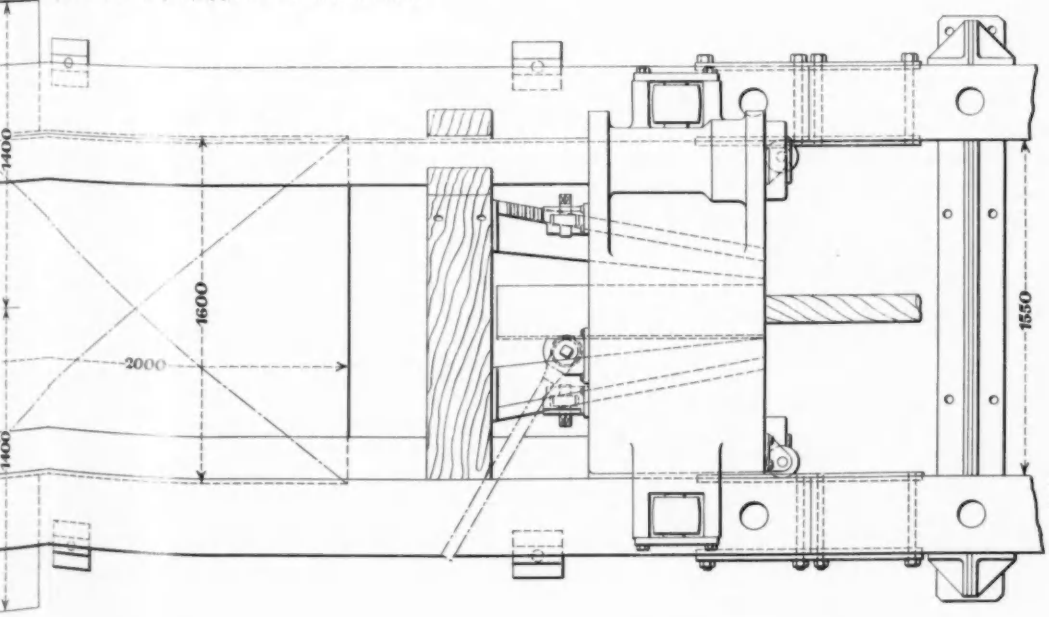
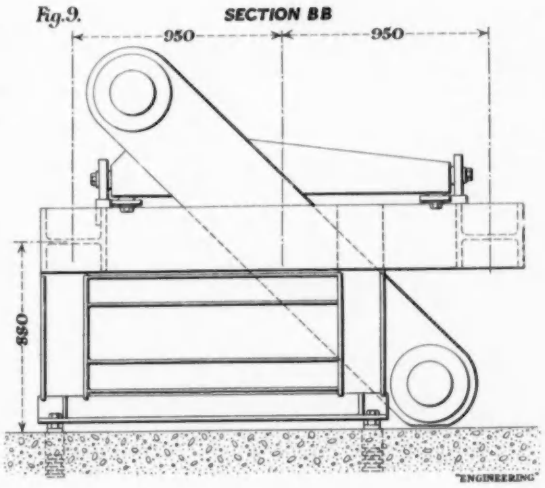


Fig. 9. SECTION BB



"ENGINEERING"

UNIV. OF MICH.

ENGINEERING.

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CONTENTS.

	PAGE
800-Ton Hydraulic Testing Machine (*Illus.*)	201
Literature.—Sound Transmission in Buildings. Non-Ferrous Foundry Practice. Generation and Transmission	202
Debtor and Creditor in Wartime	204
The Orcutt Hydraulic Gear-Tooth Grinder (*Illus.*)	204
The Aviemore Accident on the L.M.S. Railway	206
The Future of British Civil Aviation	207
The Properties and Applications of Witherite	208
British Standard Specifications	208
Personal	208
Books Received	208
Notes from the North	209
Notes from Cleveland and the Northern Counties	209
Notes from South Yorkshire	209
The Progenitors of Electricity Supply	211
The Air Attacks on London	212
Notes	213
Acceleration Diagrams for Mechanisms (*Illus.*)	213
Letter to the Editor.—The Wear-Load Characteristics of the Four-Ball Test with Various Lubricants	216
Cylinder Liner Wear in Gas Engines	216
Electrically-Driven Continuous-Chain Saw (*Illus.*)	217
Notes on New Books	217
Labour Notes	218
Fatigue and Static Failure	218
Liquefied Petroleum Gases in the United States	220
"ENGINEERING" Patent Record (*Illus.*)	220

One Two-Page Plate.—800-TON HORIZONTAL TENSILE AND COMPRESSION TESTING MACHINE.

ENGINEERING

FRIDAY, SEPTEMBER 13, 1940.

VOL. 150. No. 3896.

THE PROGENITORS OF ELECTRICITY SUPPLY.

THE type of history book on which many of us were nurtured, and which is made up of chapters headed "William I," "William II," and so on, is now regarded as obsolete. History, we are told should consist of connected accounts of human relationships, the development of governmental methods and the progress of great movements. The accidents of the emergence of a particular ruler, or political party are held, in general, to have had little effect on the progress or retrogression of affairs. The modern historian, holding this faith, frequently pays great attention to literary and artistic movements, in addition to those of a sociological character, but seldom does justice to the parts which science and technology play in social progress. Despite, however, the moulding influence which certain writers or schools of thought have had on social development, it is doubtful if any are as much responsible for the present structure of society as engineering and chemical technology.

It is true that social historians frequently pay attention to what they term the "industrial revolution." They look upon this as a movement in which handicrafts and home labour were replaced by machine manufacture and factory life, but seldom attempt to trace its influence in detail. Placing its beginnings in the Eighteenth Century, and its full flood in the early part of the Nineteenth, they are inclined to consider it as a self-contained phenomenon which had profound influence on the status of labour and the structure of industry. From the points of view of labour organisation and labour legislation, this restricted consideration is a useful working postulate, but it is incomplete and in the broader aspects of the whole matter is misleading. Actually, the expression the "industrial revolution" is a misnomer. No "revolution" occurred in the industrial field in the Eighteenth Century. All that happened was that a movement which can be traced back into the Middle Ages or farther, and which is still in full flow, was marked by one of the larger waves which may be seen in any incoming tide. Men have always used what machines they could get, and the workshops of the members of the medieval guilds differed in no essential from the cotton mills of Lancashire.

Throughout the whole course of history, vaguely even through the mist of the Dark Ages, the progress of science and technology can be traced. These are the influences which have determined the constitution of present-day society. To say this is in no way to minimise the beneficent influence of the great humanists and the great legislators of the past; merely to emphasise that the incidence of their doctrines and example in modern life is conditioned and determined by the technical structure by virtue of which the civilised world exists. Had Paracelsus, Galileo, Newton, Faraday, and other "dreamers on the hill tops," never lived, the work of the great social reformers might not have been lost, but its influence would have operated in a world of very different structure from that which we now know.

One of the controversies with which historians have amused themselves concerns the influence which "great men" have had on the development of affairs; but they usually confine the term "great" to such individuals as Constantine the Great, Charlemagne and Napoleon. Those holding the "great man" theory contend that it was these outstanding personalities who moulded the development of affairs. Their opponents hold, on the other hand, that these leaders were but the expression of the spirit of their day and that matters would have developed in much the same way had they never been born. Although the question of the influence of Constantine the Great may be left to the lay historians, the bearing of this controversy on the contention that it is science which has shaped the world cannot be ignored. Whatever may be the case in humanistic affairs, it is clear that in the march of science, as it affects society, two types of individual are concerned. The pure scientist may lay the foundations, but it is the technician or engineer who brings the work to fruition.

This may be well illustrated by a branch of work which to the historian, dealing with the broad sweep of history, may seem a minor matter, but which is, none the less, conditioning the existence of millions of mankind. The public supply of electricity in this country dates back no farther than the year 1878 and yet to-day the capital invested in the business by public and private undertakers amounts to some seven hundred million pounds, and practically every industry and almost every individual enjoys the benefit of its service. Although, giving proper credit to the work of other fundamental investigators, the immense activity which this figure represents may be traced back to Faraday's laboratory in the Royal Institution, it would be neither good history, nor fair to those who developed his work to practical ends, to hold Faraday the creator of this great component of the present-day structure of society. The proper distribution of the credit between the original discoverer and those who apply his results is both an unnecessary and impossible task, but it is no depreciation of the fame of Faraday, or of those of other originators, to say that much of the credit for present attainments must go to the engineers who bridged the gap between his Royal Institution apparatus and the 100,000-kW alternators at Battersea power station.

In the development of electricity supply, as in that of other technical industries, a third figure appears in addition to the originating scientist and the engineer. For convenience, this individual may be referred to as the financier. The engineer may have the genius to develop the crude appliances of the scientist to the stage of practical machinery, and may have faith in the possibilities which he foresees, but, in general, he has not the financial means to carry his ideas to a commercial stage. Some engineers have sacrificed all they had, and at times a good deal of the means of their friends, in efforts to this end, but usually it has been necessary to seek the aid of a third party—the financier. In the general distribution of praise to the members of the triumvirate so formed, it is to be feared that this third party has not received his meed. The engineer is sustained by his natural interest in developments for which he himself is responsible. The financier, however, who has no proper technical grasp of what is going forward, must be gifted with vision of a rare order. He must be able to foresee the commercial and social possibilities of a new development, even though he does not understand its essentials.

Public electricity supply furnishes a striking example of this vital part which the financial supporter plays in the introduction and development of a new technical industry. This is well illustrated by the history of the Deptford station of the London Electric Supply Corporation. Deptford, although not the first generating station erected to supply electricity for town service, may well be considered the nucleus from which the whole modern electricity supply industry has grown. It adumbrated what may now be considered the standard practice of the world—the distribution of high-tension alternating current through step-down substations. The story of the early days of the station, so indissolubly associated with the name of Ferranti, has often been told and need not be repeated here, but attention may well be drawn to a recent book* in which Mr. R. H. Parsons tells it anew and relates it to the early days of the other power stations which appeared in various parts of the country in the early 'eighties.

Mr. Parsons does not concern himself with the main thesis of this article, but furnishes plenty of data to support it. The beginnings of Deptford may be laid in New Bond-street, where, in 1883, Sir Coutts Lindsay put down a station for the lighting of the Grosvenor Gallery. This had its share of troubles, but after Ferranti entered the service of the operating company in 1886 the measure of success achieved was felt to be sufficient to justify, in 1887, the formation of the London Electric Supply Corporation, which built the Deptford station. The company had a subscribed capital of 535,000*l.*, Lord Wantage holding shares to the value of 220,000*l.* and Sir Coutts Lindsay, 48,885*l.* Ferranti's bold ideas for Deptford were fully supported for some years by these and the other shareholders, but finally they were unable to follow him further and he severed his connection with the company in 1891. This, however, was not evidence that they had ceased to believe in the future of electricity supply. They had lost faith in the dreamer, not in his dreams. They persevered through difficult times and although by 1898 they had lost 400,000*l.*, established a business which is now one of the main suppliers of electricity to London. Mr. Parsons' tribute to the "indomitable tenacity of Lord Wantage and other large shareholders" is well merited. Another example of the part played by the financier is furnished by the history of the Paddington power station of the Great Western Railway, with which Mr. Parsons deals in detail. The success of the station was due to the brilliant work of J. E. H. Gordon, but, again, he would not have been able to make this contribution to the future of electricity supply had it not been for the support of Sir Daniel Gooch.

The insistence on the importance of financial support does not imply that most engineers will be more interested in the business than in the technical side of the early days of the industry. This is evidently realised by Mr. Parsons, and although he has paid some attention to finance, his book in the main is a record of the engineering features of the early tentative days. He has collected a remarkable amount of detail and has produced a work which all who are interested in the development of electrical machinery and apparatus should possess. The various controversies of the early days, such as the rivalry between direct and alternating current, are dealt with, and are given particular interest by the descriptions of the various stations and the generating machinery concerned. A pleasing feature of the volume is the series of happily-chosen quotations which follow the chapter headings, although some may feel that the gas engine is treated rather hardly when the chapter devoted to it begins with Tennyson's line: "This Power hath worked no good to aught that lives." The quotation following the title of the first chapter has direct application to the genius of the engineer, inspiring a faith in others in the possibilities of new technical developments: "his look, or a word he hath spoken, wrought flame in another man's heart."

* *The Early Days of the Power Station Industry.* By R. H. Parsons, M.I.Mech.E., M.E.I.C. Cambridge: The University Press. [Price 15*s.*]

THE AIR ATTACKS ON LONDON.

THE intensification of air warfare in the London area during the past week has already given a thorough testing to the defence and A.R.P. services of the Metropolis, and it may be said that, so far, the organisations and the public have responded nobly to the calls made upon them. The attacks have been heavy and, favoured by exceptionally good weather conditions, were at first aimed mainly at objectives of some military importance, such as docks and neighbouring aerodromes. Latterly, however, when cloud prevented accurate observation, it became evident that the German pilots, unlike the British who have been carrying out the night raids over Germany and German-controlled territory, had no instructions to return with their bomb loads when any particular target was obscured. Bombs were dropped indiscriminately in districts where no legitimate objective could have been expected to exist; legitimate, that is, in the sense accepted among decent peoples, for any civilian and any property is a legitimate target according to the tenets of Nazi warfare. A number of casualties have been caused, as the official bulletins have announced; but they are many fewer than might have been expected from the scale of the attacks, and only confirm the general thesis that, of all the methods of military offence, air bombing is one of the least efficient in proportion to the effort expended.

The legend of British "aggression" and general war-mindedness is still being sedulously propagated by the energetic publicity agents of the Axis Powers, but, to any unbiassed observer, possessing even a superficial acquaintance with this country and its capital, it must be obvious that no city could be less advantageously disposed than London, on the basis of present-day military considerations. Initially, there is no doubt, the military considerations of some prehistoric era determined the site of the original encampment from which the modern London has developed; but every detail of the layout of the Greater London of to-day proclaims a complete disregard of the risks of war and even the probable needs of defence. The disadvantages of situation are inescapable and are shared by many British and Continental centres of approximately equal antiquity; in any case, the vulnerability to air attack would not be greatly reduced even if London were on the west coast, and it is only in respect of air attack that the strategic position of the city is materially worsened. The risk of an assault by sea is less acute now than it was in the Seventeenth Century, when the Dutch sailed up the Medway (piloted, incidentally, by British seamen who had abandoned all hope of obtaining their arrears of pay by any other means); and a successful attack by land still requires, as a necessary preliminary, the defeat or evasion of the sea defences.

It is in the general arrangement of its commercial and other districts, and of the essential services, that London demonstrates its deep-rooted and incurable unmilitarism. The docks are where they are because economic, geographical and navigational considerations dictated the original positions, and subsequent development proceeded by a succession of extensions. Warehouses naturally grouped themselves near the docks; smaller distributing centres grew up in the vicinity of railway termini, which themselves were often inconveniently sited because the railways entered so late into the economic life of a city which was already considerable in size. Later came 'bus services, tramways, underground and semi-underground railways, gasworks, power-stations—laid out, in every case, from purely commercial considerations, and with no preconceived notion of the co-operation that is now being enforced by circumstances upon the entire population of Greater London.

The gas works are situated along the river banks, wherever possible, to obtain the advantages of water transport of coal; power stations also, partly for this reason, and partly because of the immense volume of circulating water required by the large modern plants. These are very important considerations; but they are not insuperable, and a more military outlook undoubtedly would have disposed these public utilities differently, in addition to insisting upon the incorporation in the original design of buildings, and the layout of communicating and distributing pipes and cables, of protective features which subsequently had to be added or improvised. The arrangement of mains of all kinds, primarily with a view to ready accessibility without too much disturbance to adjacent residential and commercial interests or social amenities, is a relic of days when faults were much more common than they are to-day, and has persisted mainly because of the great expense of introducing any extensive system of piping and cable subways. This disability, of course, is not peculiar to London; in fact, there has been good evidence that Berlin itself is equally vulnerable in this respect. The siting of hospitals close to main roads or railways, which are legitimate military targets, is a direct result of a desire to have hospital facilities available at the centres of population; but this suggests that a sounder practice would be to maintain them at such vulnerable positions predominantly as casualty stations, transferring to outlying hospitals as many as can be moved of those who are likely to remain cot cases for any considerable length of time.

The absence, in normal times, of any general interworking between transport services is, perhaps, the most widespread defect from the civilian point of view. It is now announced that point-to-point travellers in the area of the London Passenger Transport Board may proceed by almost any route to their destinations, in the event of temporary interruption of particular services; but the relief that this permission might afford is materially lessened by unfamiliarity, on the part of many such bread-and-butter travellers, with the other routes that may be available but which, in normal times, they are not at liberty to use. Even the railway grouping of 1922 often proves to be only skin-deep when any question arises of using a ticket, issued for a certain route, to travel by some parallel, more convenient, or possibly more direct, line to the same destination.

Fortunately, the Londoner possesses, if anything, even more than an average adaptability, and the speed with which the public in general have readjusted their normal routine to meet unaccustomed circumstances has been truly remarkable. Much further readjustment is necessary, however, if a reasonable proportion is to be maintained between the periods of working and of resting. The modified system of air-raid warnings, in which the first syren is to be regarded as an "Alert" only, to be followed, if necessary, by a "Take Cover" signal, given by a roof watcher, should go far to correct the present anomalous position in many offices and factories. It has been observed on many occasions that staffs do not hesitate to face the risk of being caught in a raid while travelling from and to their homes, even though much of their working period may have been spent in a shelter. In a majority of cases, there is no more risk in continuing at work than in going to or away from it—sometimes much less—and it is obviously desirable that interruptions should be reduced to the minimum, in the interests of export trade as well as of munitions production.

It is quite possible that, out of this present evil, eventual good may come, in the form, first, of some voluntary and individual redistribution of the population, so as to avoid long daily journeys to and from work; and subsequently, by the making permanent of a much greater flexibility in the permissible use of transport services, which, after all, are largely responsible for persuading more and more people to live away from their work. The redistribution of other vulnerable public utilities, the better protection of mains, and the instituting of precautions to ensure that war conditions do not enhance the reciprocal risks between adjacent properties, are matters which must be left to the future; but it is abundantly clear that, if aerial warfare cannot be abolished—an ideal which, unfortunately, seems rather remote—such points as these must be regarded as among the fundamental principles of town-planning.

NOTES.

THE POSITION OF THE COAL INDUSTRY.

ON some industries the war has imposed a heavy overload, with which they are dealing with praiseworthy efficiency, while to others it has brought a state of stagnation which it is desirable that every effort should be made to relieve. Perhaps the most important member of the second class is that Cinderella of trades—the coal industry, which, owing to the defection of France and the overrunning of many erstwhile neutral countries, has suffered a considerable reduction of exports. The result is, as Mr. Lawson pointed out in the House of Commons last week, that unemployment has increased by thousands in certain areas of South Wales and Durham. He considered that this position should have been foreseen and that the Government should have produced some system of work sharing. He was supported by Mr. S. O. Davies, who complained, with some justification, that it was wrong for men to be unemployed in one district and to be working overtime in others. In reply, Mr. D. R. Grenfell, the secretary of the Mines Department, though he did not touch very closely upon the point at issue, gave an account of the position in the coal industry, from which it is possible to gather fairly well how the position stands. We were, he said, now producing more coal than we had produced for many years past, with a smaller number of men. From January 1 to September 1, the excess over the same period of last year was 3,000,000 tons, while the total was equivalent to 5 tons per head of population, 4 tons of which were being consumed for industrial purposes. In Germany and her occupied territories there was not more than one ton per head. In addition, we had ample supplies of liquid fuel. It had been arranged to export 3,500,000 tons of coal per month, but this had been reduced by 2,000,000 tons per month owing to the cessation of the demand from Holland and Belgium. As regards sharing between districts, he was not optimistic, owing to the differences in quality. With regard to the position during the coming winter, however, he was more cheerful; and it is to be hoped that there will be none of the shortage which was caused last year by a combination of defective organisation and bad weather. The Mines Department, he said, had been adding to the stocks of coal in the country at the rate of 750,000 tons a week, of which 250,000 tons was for household purposes. The emergency stock amounted to 22,000,000 tons, in addition to what might be standing round the pit heads, and this stock was being added to daily. They would not like any pit to go out of production until it could be guaranteed that all requirements had been supplied.

INSURANCE AGAINST AIR-RAID DAMAGE.

At the beginning of the war a Committee, under the chairmanship of Lord Weir, considered and decided against the possibility of an insurance scheme which would guarantee payment to those whose property suffered as the result of air raids. This decision, which did not receive universal acceptance, was based on the supposition that the damage might be so widespread that no actuarially sound scheme could be devised to pay for it. Indeed, it was felt that the best that could be done would be to advance money free of interest temporarily, so that essential repairs could be effected, and to leave the main problem of compensation to be dealt with until after hostilities had been concluded. There is evidence that what has been done in this direction so far has not been effected entirely without friction. Advances are being made on the basis of prices as they stood in May, 1939, which means that a wider or narrower gap has to be bridged by the sufferer out of his own resources if his property is to be made habitable. There are also the usual complaints of bureaucratic lack of imagination in dealing with the claims. Finally, damage due to air raids, even taking into account the events of the past few days, has not been so widespread as was expected, and there is, therefore, good reason why the position should be reconsidered. In fact, the Prime Minister put the number of houses destroyed or damaged beyond repair, up to the end of August, at 800 out of a total of 13,000,000. We are therefore glad to learn that the Government has decided that the possibilities of an insurance scheme are worth further examination, and that payments for damage to furniture and clothing are to be made on a more generous scale than hitherto, and are to be extended to cover workmen's tools and the stocks of small retailers. We hope that the Committee appointed for this purpose will deal with the problem on the broadest lines and will submit its report without undue delay. This is eminently a case where actuarial soundness and rigid legality must give place to something more flexible and openhearted, especially as by so doing anxiety will be relieved and the burden spread more evenly over the whole community. By this time, as the Prime Minister has pointed out, the authorities should have obtained the measure of the potential damage that may be caused and should set their course accordingly.

PUBLIC VEHICLE TRANSPORT IN WAR TIME.

It is a little unfortunate that the movement which was taking place in all parts of the country to convert the tramway services to a more flexible form of transport should have preceded a war in which petrol will be a most important, if not a deciding, factor. The most favoured change has been from the tram to the omnibus driven by an internal-combustion engine, though, in some cases, the trolley 'bus has been substituted. This problem is dealt with by Mr. H. J. Troughton in a paper which was to have been read at the summer meeting of the Municipal Passenger Transport Association. In this he considers various alternatives to the use of petrol and Diesel oil for passenger transport, and makes the rather surprising suggestion that creosote might be more widely employed for the production of the necessary liquid fuel. To do this, however, would mean the provision of a large amount of equipment, and much expense, both of which are likely to raise almost insuperable difficulties at the present time. He advocates compressed gas as another alternative, and this seems more feasible, but he dismisses producer gas, perhaps too summarily, on the grounds of expense. His most interesting and practical suggestion is, however, that the trolley 'bus might be more widely used. Mr. Troughton correctly points out that a number of motor-'bus services at present duplicate trolley-'bus routes before leaving for branch roads, and that it would be both cheap and easy to provide these roads with the necessary overhead equipment, so that trolley 'buses could also be used on them. It might be possible to do this without increasing the existing sub-station capacity, but this would only mean a reduction in voltage and speed. As regards rolling stock, it should not be difficult to convert existing motor 'buses for the purpose. These suggestions are worth considering, not only as a means of relieving the fuel situation, but because, in certain areas, the road transport needs to be augmented and experience has shown that the trolley 'bus is suitable for this purpose.

ROAD CONSTRUCTION AND FLOOD PREVENTION IN SHANGHAI.

In addition to the more spectacular effects, which are duly noted in our daily contemporaries, the wars —both Asiatic and European—seem to have caused difficulties of an engineering and economic character in Shanghai. According to the Report of the Commissioner of Public Works to the Municipal Council for the year 1939, the main feature of the year was a further increase in the heavy road traffic, combined with still more restricted supplies of materials for road maintenance. It is noted that the iron-tyred hand trolleys, which do so much damage to the road surfaces, increased by 5,000 to 17,500 during the year, while the number of heavy freight vehicles was 70 per cent. higher than before the hostilities. To make matters worse, no material could be obtained from the Council's quarry and the supplies of road stone from all sources was only 8 per cent. of the normal. Means for reconditioning and re-using all materials from worn-out roads have, therefore, had to be devised, and even pulverised crockery and sand reclaimed from old mortar have been pressed into service. Nevertheless, it was possible to reconstruct parts of a number of important roads, with an aggregate area of 280,000 sq. ft., in concrete. In view of the shortage of first-class stone, however, it has now become necessary to separate it from old road metal recovered during repairs and, after suitable cleansing, to re-use it in asphalt concrete and granolithic surfacing. The dust nuisance on ash roads was counteracted by using calcium chloride in a mixture of ash and a filler such as decomposed granite. Difficulty was also caused in connection with the roads, owing to extensive flooding. This occurred in the extra-Settlement areas and resulted in damage to macadam road surfaces. To alleviate this, extensive cleaning of main drains was carried out during the year and special relief drains were laid in two areas. It was evident, however, that the natural creek drainage system west of the Settlement boundary had been irreparably damaged by the abnormal development of the area during the past two years and that other means for discharging flood water would have to be found. Towards the end of the year, therefore, a scheme for utilising a main soil sewer, in conjunction with additional pumps in the sewage pumping stations, was devised for discharging the flood water. Similar means were employed in another area and the anti-tidal measures on the Bund were improved by the construction of ramps at all the jetties where river water could overflow. Considerably more new drainage work was carried out than in 1938, and both the Eastern and Western Sewage Treatment Works were re-started, the new tanks at the latter being brought into use. The flood prevention system functioned on 153 occasions during the year, on only five of which were any parts of the protected area flooded. On four of these occasions the cause was heavy rainfall which, combined with normal drainage, exceeded the capacity of the pump. On the fourth occasion the river rose nearly 4 ft. above parts of the district and entered over the French Bund.

ACCELERATION DIAGRAMS FOR MECHANISMS.

By E. GIFFEN, Ph.D., D.Sc., M.I.Mech.E.

THE accelerations of points and links of a mechanism are most readily determined by drawing the vector acceleration diagram. For certain special cases, such as the reciprocating-engine mechanism, special geometrical constructions have been evolved; but for mechanisms in general, the vector acceleration diagram provides the general solution, giving the linear acceleration of any point, and the angular acceleration of any link in the mechanism. Many examples of the application of this method will be found in the standard text-books dealing with mechanisms and machines. In most of these, however, the method is not extended to its fullest use, and could not be applied directly in many comparatively simple mechanisms met with in general engineering practice. The simple treatment usually given is applicable only to mechanisms in which the moving links are all of fixed lengths; it could not be used, for instance, with the swinging link quick-return mechanism, or any mechanism in which one link slides in another while the second link is itself in movement. In those text-books in which problems of the latter type are considered, they are often dealt with as special cases, requiring the introduction of new conceptions, and causing considerable difficulty and confusion.

In the following treatment it is shown that the construction of the acceleration diagram for any mechanism is based primarily on a single fundamental relationship; this expresses the acceleration of a point moving in any given path in a plane in terms of the radial and transverse components relative to some other given point in the plane. The application to any mechanism varies with the individual conditions governing the movements of the various points, but it is shown that, in general, these may be dealt with by applying the results obtained from two simplified cases of the

ACCELERATION DIAGRAMS FOR MECHANISMS.

general problem. One of these simplified cases applies to links of fixed length, and is, in fact, the conventional case referred to above, as given in most text-books; the other applies to links having sliding connections. The derivation of the radial and transverse accelerations of a given point relative to some other point is usually carried out by the analytical method, and is given in most of the more advanced text-books dealing with kinematics.* For the purpose of the present treatment, however, it is convenient to use the vector velocity diagram, since the whole problem is bound up with the representation of relative velocities and accelerations by means of vectors.

In Fig. 1, the point under consideration is tracing out the curved path shown, and in time δt has moved from A to B on this path. It is required to find the radial and transverse components of its acceleration, relative to the point O. In the position A, its instantaneous velocity may be represented by the two components along and perpendicular to the line OA; v is the radial velocity, and $r\,\omega$ the transverse velocity, where r is the length of the radial line O A and ω is the instantaneous angular velocity of this line in the clockwise direction. After a time δt the radial line has moved through an angle $\delta\,\theta$ to the position O B, the length of which is $r + \delta r$ and the angular velocity $\omega + \delta\,\omega$; the radial velocity also has increased to $v + \delta\,v$. Figs. 1 (*a*) and 1 (*b*) show the vector diagrams of velocity for the radial and transverse components, respectively. The change in radial velocity is given by the line $a\,b$ (Fig. 1 (*a*)), and this may be resolved into its radial and transverse components:—Radial component of $a\,b = c\,b = \delta\,v$; transverse component of $a\,b = a\,c = v\,\delta\,\theta$. Similarly, the change in the transverse velocity is given by $a'\,b'$ (Fig. 1 (*b*)), and this also has its two components:—Radial component of $a'\,b' = a'\,c' = -r\,\omega\,\delta\,\theta$, the negative sign denoting a velocity inwards towards the point O; transverse component of $a'\,b' = c'\,b' = (r + \delta\,r)(\omega + \delta\,\omega) - r\,\omega = \omega\,\delta\,r + r\,\delta\,\omega$. Combining the radial and transverse components, we have the total change in velocity along the radius in time $\delta\,t = \delta\,v - r\,\omega\,\delta\,\theta$, and the total change in velocity perpendicular to the radius in time $\delta\,t = v\,\delta\,\theta + \omega\,\delta\,r + r\,\delta\,\omega$. Hence, the radial acceleration

$$= \frac{\delta\,v}{\delta\,t} - r\,\omega\,\frac{\delta\,\theta}{\delta\,t},$$

or, in the limit

$$\frac{d\,v}{d\,t} - r\,\omega^2,$$

and the transverse acceleration is

$$v\,\frac{\delta\,\theta}{\delta\,t} + \omega\,\frac{\delta\,r}{\delta\,t} + r\,\frac{\delta\,\omega}{\delta\,t},$$

which gives

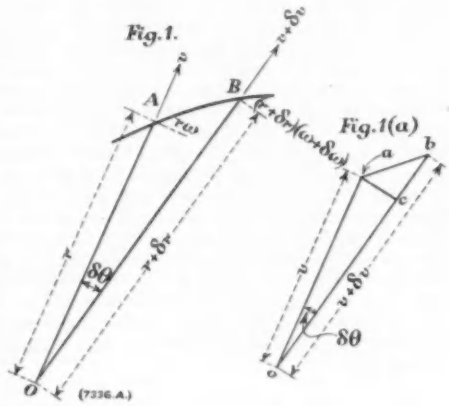
$$2\,\omega\,v + r\,\frac{d\,\omega}{d\,t}.$$

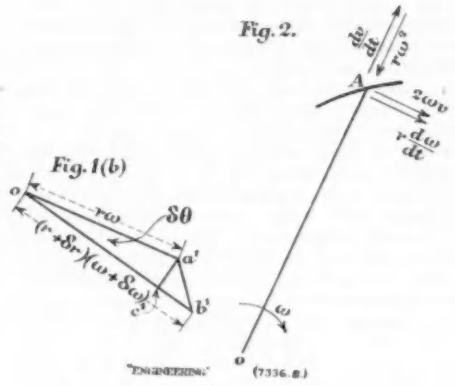
These expressions for the radial and transverse accelerations provide the principle underlying the construction of the acceleration diagram for a mechanism. The components are shown in Fig. 2, and it may be noted that if $\frac{d\,\omega}{d\,t}$ is positive the acceleration $r\,\frac{d\,\omega}{d\,t}$ acts in the direction of the angular movement. Similarly, if v is positive, *i.e.*, if the point is moving radially outwards, the acceleration $2\,\omega\,v$ also acts in the direction of angular movement; with v negative the direction of this component $2\,\omega\,v$ would be reversed.

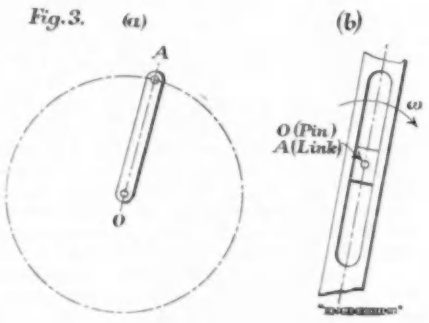
The general expressions given above may be modified to suit special conditions governing the movement of the point. The two special conditions of importance in mechanisms are shown in Fig. 3, (*a*) and (*b*). Fig. 3 (*a*) represents rotation in a circular path, and applies to all links of fixed length. Here, both v and $\frac{d\,v}{d\,t}$ become zero, so that the radial acceleration of A relative to O becomes $-r\,\omega^2$, and the transverse acceleration $r\,\frac{d\,\omega}{d\,t}$. Fig. 3(*b*) represents the case of a block sliding in a guide which is itself moving in the same plane. Here A is a point on the link coincident with O, the centre of the block; ω is the angular velocity of the link, and v is the radial velocity of A relative to O. The direction of this radial velocity is along the guide, so that the radial velocity v is the sliding velocity of the guide relative to the block. The radius r is zero in this case, so that the general expressions for the accelerations become: radial acceleration $= \frac{d\,v}{d\,t}$ and transverse acceleration $= 2\,\omega\,v$. The direction of the transverse component may easily be determined by remembering that this component leads the vector representing the sliding velocity by 90 deg., measured in the direction of rotation of the link. When the link is fixed, $\omega = 0$, and the problem reduces to the simple case of a linear acceleration $\frac{d\,v}{d\,t}$ along the fixed guide. Fig. 4 (*a*) and (*b*), shows portions of two mechanisms in which the two different conditions are applied. In each case it is to be assumed that the acceleration of A relative to the earth is already known. The end C of the link B C is attached to a fixed pin at C, and it is required to determine the acceleration of B. The respective acceleration diagrams are shown in Fig. 5 (*a*) and (*b*). In each case, the point c_1 represents zero acceleration relative to the earth, and $c_1\,a_1$ the known acceleration of A relative to the earth. The acceleration of B is then obtained by considering, first, the acceleration of B relative to A, and second, the acceleration of B relative to C.

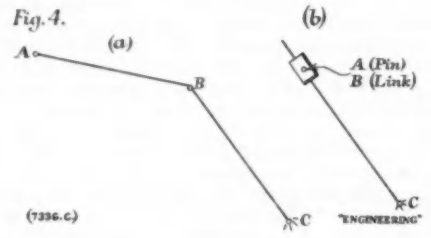
For the conditions shown in Fig. 4 (*a*) the links are each of constant length, so that for each the radial acceleration is $-r\,\omega^2$ and the transverse acceleration is $r\,\frac{d\,\omega}{d\,t}$. The construction used for the acceleration diagram is the same as that given in the standard text-books; it is repeated here, however, in order to serve as a basis for comparison with the method to be described for the conditions of Fig. 4 (*b*). For the link A B in Fig. 4 (*a*), the radial acceleration of B relative to A is given by $\omega^2_{AB}\cdot$A B, where ω_{AB} denotes the angular velocity of the link A B, determined from a vector velocity diagram. Thus, in Fig. 5 (*a*), $a_1\,b_a$ is drawn in the direction from B to A, and made equal to $\omega^2_{AB}\cdot$A B; a line drawn through b_a, and perpendicular to $a_1\,b_a$, will contain the transverse acceleration component, which is at present unknown. In a similar manner the radial acceleration of B relative to C is determined and $c_1\,b_c$ is drawn from c_1 in the direction from B towards C. Through b_c a line is drawn perpendicular to $c_1\,b_c$, and the transverse acceleration of B relative to C, at present unknown, will lie along this line. The intersection b_1 gives the acceleration of the point B. Thus we have, from Fig. 5 (*a*): Acceleration of B relative to the earth $= c_1\,b_1$ and acceleration of B relative to A $= a_1\,b_1$. The angular acceleration of either link may also be determined from the acceleration diagram, since for each link the transverse component represents $r\,\frac{d\,\omega}{d\,t}$. Thus the angular acceleration of A B is $\frac{b_a\,b_1}{\text{A B}}$, anti-clockwise, and the angular acceleration of B C is $\frac{b_c\,b_1}{\text{B C}}$, clockwise.

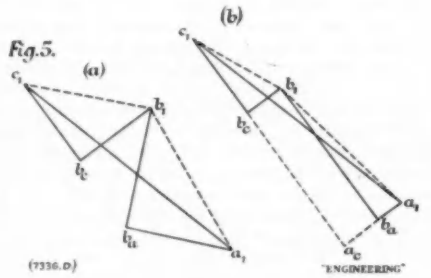
The acceleration diagram for Fig. 4 (*b*) is shown at Fig. 5 (*b*). As before, the resultant acceleration of A relative to the earth is known, and is represented by $c_1\,a_1$. Considering first the acceleration of B relative to A, the radial and transverse components are as given for Fig. 3 (*b*). In this case the magnitude of the radial acceleration, $\frac{d\,v}{d\,t}$, is so far unknown, but the transverse acceleration, $2\,\omega\,v$, may be obtained from the vector velocity diagram. The radial velocity v is the sliding velocity of the point B on the link relative to the block, and the angular velocity ω is that of the link B C. If it be assumed that the direction of rotation of the link is clockwise, and that the sliding velocity of B relative to A is in the direction B C, both having been found from the velocity diagram, then the direction of the transverse acceleration is as shown by $a_1\,b_a$, leading the direction of the sliding velocity by 90 deg. measured in the direction of rotation. The radial acceleration of B relative to A will be along the





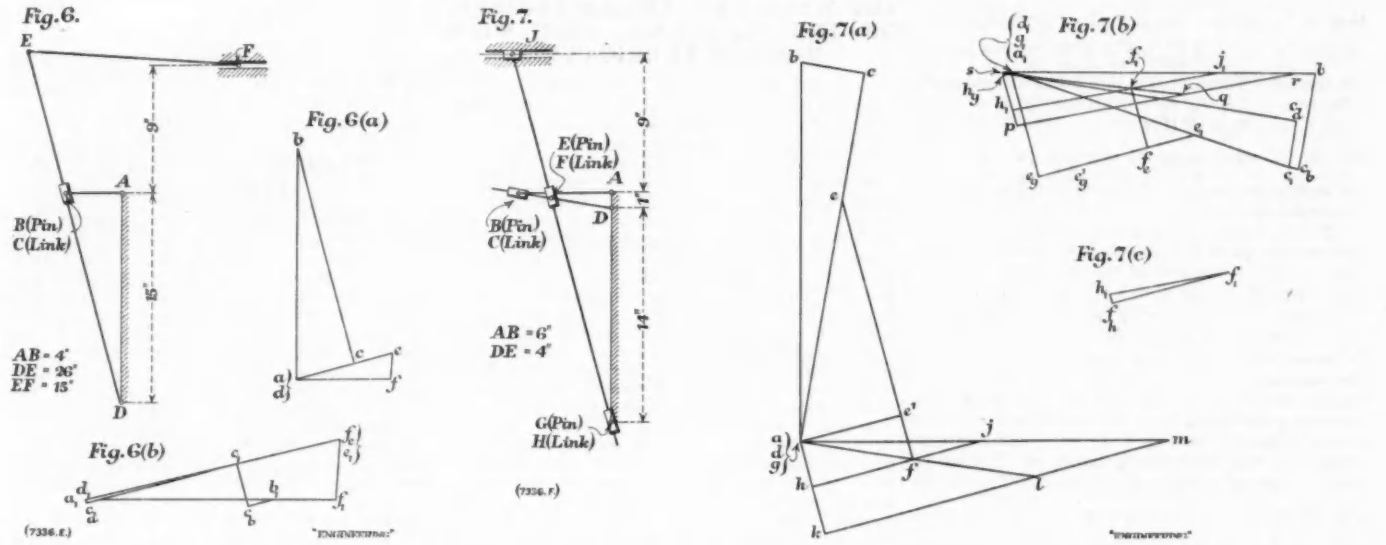






* Toft and Kersey, *Theory of Machines*, Pitman. Prescott, *Mechanics of Particles and Rigid Bodies*, Longmans.

ACCELERATION DIAGRAMS FOR MECHANISMS.



line drawn through b_a and perpendicular to $a_1 b_a$. The acceleration of B relative to C is treated as in Fig. 5 (*a*), since B is, for the instantaneous position of the mechanism, a fixed point on the link B C. The radial acceleration of B relative to C is, therefore, $\omega^2_{BC} \cdot B C$, and is represented by $c_1 b_c$, as before, and the transverse acceleration will be perpendicular to this line. The intersection of the perpendiculars through b_a and b_c gives b_1, representing the resultant acceleration of B.

The acceleration of B relative to C, that is, to the earth, is then given by $c_1 b_1$, and the acceleration of B relative to A is given by $a_1 b_1$. It may be noted, further, that the component $b_a b_1$ gives the direction and magnitude of the radial acceleration of B relative to A, or, alternatively, that the linear acceleration of the block A relative to the link B is given by the component $b_1 b_a$. The angular acceleration of the link B C is given, as before, by $\frac{b_c b_1}{B C}$, and, for the conditions chosen, is in the clockwise direction.

It is necessary in some of the more difficult problems involving sliding connections, such as the second example worked out later, to find the angular acceleration of the link C B before sufficient information is available to fix the position of the point b_1. This may be done by considering the acceleration of A relative to C, the general case for which the acceleration components are shown in Fig. 2. The resultant acceleration is known to be $c_1 a_1$; the radial and transverse components are therefore $c_1 a_c$ and $a_c a_1$, respectively, shown dotted on Fig. 5 (*b*). Then, since the transverse acceleration of A relative to $C = 2 \omega v + r \frac{d \omega}{d t}$ and is represented by the line $a_c a_1$, and since $2 \omega v$ can be calculated from the velocity diagram and is represented by $b_a a_1$, the difference $a_c b_a$ represents $r \frac{d \omega}{d t}$. In a similar manner, the linear acceleration of the block relative to the slide may be obtained from the radial component $c_1 a_c$, which is equal to $\frac{d v}{d t} - r \omega^2$. From Fig. 5 (*b*) the component $\frac{d v}{d t}$ is represented by $b_c a_c$, since $c_1 b_c = - r \omega^2$, and it will be seen that, in the present instance, $\frac{d v}{d t}$ is negative, *i.e.*, directed towards C, the centre of rotation.

It is unnecessary to consider in greater detail the acceleration diagrams for mechanisms having only links of fixed lengths, as these are adequately dealt with elsewhere. In order to emphasise the utility of the general method for all types of mechanisms, however, it is desirable to illustrate it by means of a few practical examples, and for this purpose two mechanisms are worked out in detail below; the first is comparatively simple, but the second is of a more difficult character. The first example chosen is the simplest form of swinging link quick-return mechanism used on reciprocating machine tools. The actual dimensions of the links are given on the diagram, Fig. 6, in order that numerical values may be obtained for the various velocities and accelerations. The crank A B is rotating in the clockwise direction with a uniform speed of 30 r.p.m., and it is required to make a complete acceleration analysis of the mechanism for the position shown. The velocity diagram is shown in Fig. 6 (*a*), the points *a*, *b*, *c*, etc., corresponding to the points A, B, C, etc., on the mechanism. For the acceleration diagram, Fig. 6 (*b*), it is only necessary to enumerate the various components in the order in which they are drawn, and to indicate how the magnitudes are determined. $a_1 b_1$ = radial acceleration of B relative to $A = \omega^2_{AB} \cdot A B = \frac{(a b)^2}{A B} = 3{\cdot}29$ ft. per second per second. $b_1 c_b$ = transverse acceleration of C relative to $B = 2 \omega_{CD} \cdot$(velocity of C relative to B) $= 2 \frac{d c}{D C} \cdot b c = 0{\cdot}42$ ft. per second per second.

The direction of the velocity of C relative to B is given by $b c$ on the velocity diagram, and the rotation of the link C D is clockwise, hence the direction of $b_1 c_b$ is as shown.

Though c_b a line is drawn perpendicular to $b_1 c_b$. $d_1 c_d$ = radial acceleration of C relative to $D = \frac{(d c)^2}{D C} = 0{\cdot}06$ ft. per second per second. Through c_d a line is drawn perpendicular to $d_1 c_d$. The intersection of these two perpendiculars gives c_1. Points $d_1 c_1$ are joined and produced to e_1, making $\frac{d_1 e_1}{d_1 c_1} = \frac{D E}{D C}$. The line $e_1 f_e$ = radial acceleration of F relative to $E = \frac{(e f)^2}{E F} = 0{\cdot}01$ ft. per second per second. This is so small that f_e is shown as coincident with e_1. Through f_e a line is drawn perpendicular to E F; the transverse acceleration of F relative to E will be along this line. Through a_1 a line is drawn parallel to the fixed guide at F. The intersection of this line with the perpendicular from f_e gives f_1.

The accelerations of the various parts of the mechanism are then as follows:—The acceleration of E is represented by the magnitude and direction of the line $a_1 e_1$. The acceleration of F is represented similarly by the line $a_1 f_1$. The angular acceleration of the link D E is given by $\frac{c_d c_1}{D C}$ and is clockwise. The angular acceleration of the link E F is given by $\frac{f_e f_1}{E F}$ and is anti-clockwise. The linear acceleration of the block at B relative to the link D E is represented by the line $c_1 c_b$.

The second example, shown in Fig. 7, is a modification of the mechanism of Fig. 6, and represents the arrangement used on an actual shaping machine. The driving pin B rotates at a uniform speed of 30 r.p.m. about the fixed centre A, and drives the slotted link C D, which rotates about D. The pin E, in the link C D, drives the swinging link H J. The end J of this link is attached to the ram of the machine and moves in the horizontal fixed guide shown. The other end H is slotted to slide over the block pivoted on the pin G. This mechanism gives a double quick-return effect, and also eliminates the necessity for the link E F of Fig. 6.

Fig. 7 (*a*) is the velocity diagram for the mechanism, and, as it is not quite so straightforward as the previous case, a brief explanation is desirable. $a b$ = velocity of B relative to $A = \omega_{AB} \cdot A B = 1{\cdot}57$ ft. per second; $d c$ is drawn in the direction of the velocity of C relative to D; $b c$ is drawn in the direction of the velocity of C relative to B; the intersection gives c, representing the velocity of C; $d c$ is divided at e, so that $\frac{d e}{d c} = \frac{D E}{D C}$. In order to complete the diagram, a three-line construction is required, since three velocities have to be determined simultaneously. The method is as follows: A line is drawn through e in the direction of the velocity of F relative to E. Through g a line is drawn in the direction of the velocity of H relative to G. Through a, d, or g, the point of zero velocity, a line is drawn in the direction of the velocity of J relative to the earth. Now the velocities of H, F, and J relative to one another will be along a line perpendicular to the link H J and intersecting the three lines drawn as described above. This line is shown by $h f j$ on the velocity diagram, and it must be such that $\frac{h f}{h j} = \frac{H F}{H J}$. The construction is to draw any line $k m$ perpendicular to H J and cutting the three given lines; this line $k m$ is divided at l in the required ratio and l is joined with the vertex of the triangle a. The intersection of this latter line with the line drawn through e gives the point f, and $h f j$ is drawn parallel to $k m$. The velocity of any point relative to any other point may then be taken directly from the diagram in the usual manner.

The acceleration diagram is then drawn, as shown in Fig. 7 (*b*), the various lines being drawn in the following order:—$a_1 b_1$ = radial acceleration of B relative to $A = \frac{(a b)^2}{A B} = 4{\cdot}94$ ft. per second^2. $b_1 c_b$ = transverse acceleration of C relative to $B = 2 \omega_{CD} \cdot$(velocity of C relative to B) $= 2 \frac{c d}{C D} \cdot b c = 1{\cdot}58$ ft. per second per second. Through c_b a line is drawn perpendicular to $b_1 c_b$. $d_1 c_d$ = radial acceleration of C relative to $D = \frac{(d c)^2}{D C} = 4{\cdot}70$ ft. per second per second. Through c_d a line is drawn

perpendicular to $d_1 c_d$. The intersection of these two perpendiculars gives c_1. $d_1 c_1$ is divided at e_1, so that $\frac{d_1 e_1}{d_1 c_1} = \frac{\text{D E}}{\text{D C}}$. $e_1 f_e$ = transverse acceleration of F relative to E $= 2\omega_{\text{HF}} \cdot$(velocity of F relative to E) $= 2\frac{hf}{\text{H F}} \cdot ef = 0{\cdot}76$ ft. per second per second. Through f_e a line is drawn perpendicular to $e_1 f_e$; f_1 will be on this line. $g_1 h_g$ = transverse acceleration of H relative to G $= 2\omega_{\text{HF}} \cdot$(velocity of H relative to G) $= 2\frac{hf}{\text{H F}} \cdot gh = 0{\cdot}13$ ft. per second per second. Through h_g a line is drawn perpendicular to $g_1 h_g$; h_1 will be on this line.

The line $h_1 f_1 j_1$ will be a continuous straight line, and the two parts $h_1 f_1$ and $f_1 j_1$ will be in the same ratio as the two parts of the link H F and F J. The direction of the line $h_1 j_1$, however, will not necessarily be perpendicular to the link H J, as in the velocity diagram, and this direction must first be determined. This may be obtained by drawing the radial and transverse components of the acceleration of one point on the link (say, F) relative to another point (say, H); for convenience, this is shown separately in Fig. 7 (*c*), but could easily be drawn on the acceleration diagram. F and H, for the instant considered, are fixed points on the link, hence the radial component is $\frac{(hf)^2}{\text{H F}} = 0{\cdot}15$ ft. per second per second, and the transverse component is $\text{H F} \cdot \frac{d\,\omega_{\text{HF}}}{dt}$. The latter component is obtained from a consideration of the acceleration of E relative to G, as discussed in connection with Fig. 5 (*b*); the transverse component of $g_1 e_1$, Fig. 7 (*b*), is $e_g e_1$, and is equal to $2\omega v + r\frac{d\omega}{dt}$. Here v represents the radial velocity of E relative to G, *i.e.*, $e^1 e$ the component of $g e$ in the direction of the link H F, and ω is the angular velocity of the link. $e_g e_g^1$ is made equal to $2\omega v = 0{\cdot}64$ ft. per second per second, then $e_g^1 e_1$ represents $r\frac{d\omega}{dt}$ for the link.

In Fig. 7 (*c*), therefore, $h_1 f_h = \frac{(hf)^2}{\text{H F}} = 0{\cdot}15$ ft. per second per second, and $f_h f_1 = e_g^1 e_1 = 1{\cdot}94$ ft. per second per second. The line $h_1 f_1$ then gives the direction of the resultant acceleration of F relative to H, and the line $h_1 j_1$ in Fig. 7 (*b*) will be parallel to this direction. The actual position of $h_1 j_1$ is found by the same construction as is used for the velocity diagram; $p q r$ is any line drawn in the required direction and divided in the given ratio, and s is the vertex of the triangle. Then f_1 is found and through this $h_1 j_1$ is drawn. The accelerations of the various points and links of the mechanism may then be determined from the diagram as in the previous example, and it is unnecessary to repeat this for the present case.

The example given in Fig. 7 is one of the few problems in which the three-line construction is necessary for the completion of the velocity diagram, and the corresponding difficulty is encountered in the acceleration diagram. Only in cases such as this is it necessary to employ the general expressions of Fig. 2 for the radial and transverse accelerations of a point moving in any curved path, and even then the application is comparatively simple. In the majority of mechanisms, the general case of Fig. 2 is reduced to the two simple cases of Fig. 3, the one applying to links of fixed length and the other to sliding connections. With this method of treatment, mechanisms having sliding connections are dealt with just as easily as those having links of fixed length; the underlying principle is the same for both, and is applied with equal facility to problems of either type.

GOLDEN GATE EXHIBITION, SAN FRANCISCO.—The Golden Gate National Exposition, San Francisco, which was opened on May 25, will close on September 29.

BRICKMAKING AND BRIQUETTING MACHINERY EXPORT GROUP.—Mr. E. R. Sutcliffe has been appointed chairman of the Brickmaking, Clayworking and Briquetting Machinery Export Group. The secretaries are Messrs. Peat, Marwick, Mitchell and Company, York Mansions, 94-98, Petty France, London, S.W.1.

LETTER TO THE EDITOR.

THE WEAR-LOAD CHARACTERISTIC OF THE FOUR-BALL TEST WITH VARIOUS LUBRICANTS.

TO THE EDITOR OF ENGINEERING.

SIR,—I failed to understand both the main purpose of Dr. Schnurmann's note in your issue of June 7 and many of his statements. In order to avoid a protracted discussion and yet elucidate any points that may contribute towards an understanding of seizure phenomena, I have met Dr. Schnurmann and discussed this subject with him. It is apparent that his aim was to further the physical interpretation of the observations on seizure, but he read into my article (your issue of February 9) more than was present or intended, and made a number of statements for which the evidence is lacking.

Thus he took the terms "breakdown load" and "seizure characteristics" as having a precise meaning as to the mechanism of the behaviour, whereas I used them merely as descriptive terms. As regards the former, he said the existence of a breakdown load is "an unwarranted assumption," and that it is based on "the hypothesis that the surface irregularities penetrate adsorption layers and weld together." Actually, the term was used merely to describe the load at which, as an observational fact, a sudden increase of wear occurs. In so far as this load varies with the lubricant for a constant rubbing material, the term has been applied to the various lubricants. It is thus identical with what Dr. Schnurmann defined as "seizure load," and it is apparent that in this respect there is no difference between us. As regards welding, I used the word only in referring to the flow of plastic or molten metal which occurs at the highest loads in a series of tests, and which results in uniting the four balls, a use in the conventional engineering sense. Dr. Schurnmann interpreted my remarks as referring to the initiation of seizure, whereas I have actually been unable to offer a precise explanation of the mechanism of this behaviour. On account of this misunderstanding, Dr. Schnurmann's remarks on (1) the contrast in behaviour of the extreme-pressure lubricant, E.P. Oil E, and other lubricants; (2) the periodic peaks that should be obtained with the friction recorder of the four-ball apparatus; and (3) the comparative influence of the lubricants and the mating surfaces, no longer apply as regards any assumption or hypothesis of mine.

As regards the contention that the wear-load curve must be of the saturation type, the drawing of mean lines through plotted points is nearly always somewhat arbitrary, but there is actually little experimental evidence for rounding off the corners at the junctions of the three parts of the wear-load curve in tests with lubricants. Moreover, the high-load part of the curve is usually straight, and welding of the balls occurs before there is any sign of flattening out; in other cases, the curve is still steep when welding occurs.

Dr. Schnurmann considers that the adhesiveness of the ultimate monomolecular film is sufficient to result in plucking of particles out of a surface, and that this will occur in preference to rupture of the film itself. Such strength of the residual film would be of definite interest as regards the influence of the lubricant, compared with that of the mating surfaces, on friction, wear and seizure, and it is desirable to have the evidence on which the statement is based. Dr. Schnurmann now agrees that the sugar lump experiment is not in itself sufficient to demonstrate this phenomenon.

Similar evidence is required to justify his statement that the shearing of oxidised surfaces may occur at other than the oxide interface, and perhaps more still for the part played by oxidation and dielectric strength of the lubricant. Thus I certainly could not see the justification for the statement that "the joint action of surface oxidation, adhesion of the residual film of lubricant and contact electricity cannot lead to anything but very irregular friction-time charts," or that one of these three conditions must be fulfilled for wear to occur. In connection with electrostatic charges and dielectric breakdown strength, the explanation must take into account the fact that the balls in the four-ball apparatus are electrically connected externally; I believe that in Kyropoulos' experiments, which Dr. Schnurmann quoted, the conditions were those of fluid-film lubrication and that the effects obtained applied to the change from the insulated to the electrically-connected state.

The subject of boundary lubrication has reached the stage where theoretical suggestions must have substantial backing, otherwise there is merely a continuation of the speculative juggling with physical and chemical factors which has characterised much of the literature for so long. If Dr. Schnurmann can show reasonably conclusively the influence of oxidation and dielectric strength, some progress towards understanding the basic mechanism of seizure will have been made.

Yours faithfully,
D. CLAYTON.

Engineering Department,
National Physical Laboratory,
Teddington.
September 4, 1940.

CYLINDER LINER WEAR IN GAS ENGINES.

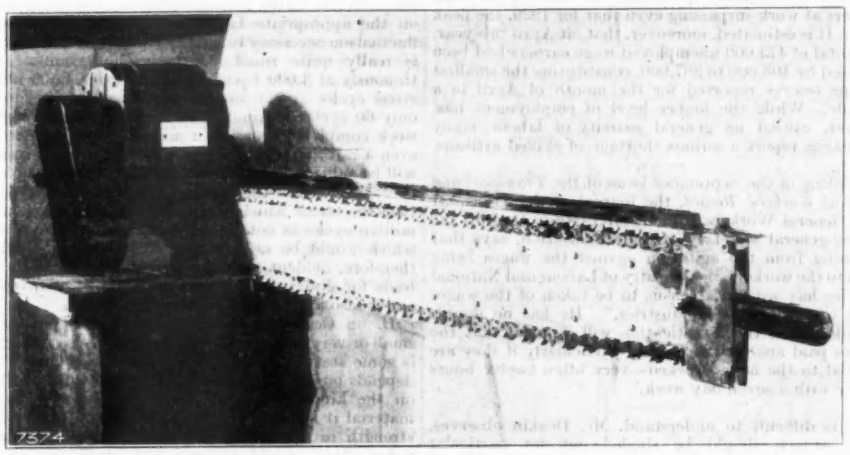
THE subject of wear in the cylinders of internal-combustion engines has for some years past received considerable attention and many of the investigations made on it have been recorded in these columns. The subject has, moreover, been dealt with in a book, *Collected Researches on Cylinder Wear*, by Mr. C. G. Williams, M.Sc., which book was reviewed in ENGINEERING, vol. 149, page 301 (1940). Nevertheless, there must be in existence interesting data still not widely circulated, and it is, therefore, useful to cite, as an example, some information collected by Messrs. The National Gas and Oil Engine Company, Limited, Ashton-under-Lyne. The engines concerned are manufactured by the firm and are those of two gas-engine installations, one of which consists of four 1,500-h.p. engines running on blast-furnace gas, while the other has six 600-h.p. engines running on producer gas generated from wood. The first-mentioned engines are situated at an iron and steel works, and of the four, two were started up in 1921 and two in 1924. Each engine is of the vertical 12-cylinder type, there being six cranks with two cylinders in tandem to each crankpin. The bottom cylinder of each pair is of the usual splash-lubricated trunk type, the top cylinder having a shallow uncooled piston with mechanical sight-feed lubrication. The running clearances are necessarily double those of the ordinary trunk type engine and the piston temperatures are, therefore, much higher than in this type.

Referring first to No. 1 engine, this had run for 98,000 hours up to 1933, when all six top cylinders were relined. The cylinder diameter is 26 in. and the wear was approximately 0·1 in. The bottom cylinders showed so little wear, viz., less than 0·0005 in. per 1,000 hours, that new liners were considered unnecessary. No. 2 engine, started up at the same time as No. 1 engine, had three top cylinders relined in 1932 after 90,000 hours running, the remaining three cylinders being relined in 1938 after 92,600 hours working. The bottom cylinders were not relined. In No. 3 engine, started up three years after No. 1 and No. 2, a seizure occurred in one top cylinder in 1931 and a new liner was, in consequence, required. Three of the other top cylinders were relined in 1933 after 72,000 hours running, and the remaining two later in the same year after 76,000 hours running. The average liner wear was approximately 0·07 in., but it was more convenient to reline the cylinders at this point than to postpone the work till the maximum allowable wear of 0·1 in. had been reached. No. 4 engine, also started up in 1924, had three top cylinders relined in 1934 after 86,000 hours running, the other top cylinders being relined in 1936 after 101,300 hours running. It would seem to be fairly well established that the rate of wear in the top cylinders of the engines averages 0·001 in. per 1,000 hours running. The rate of wear on the bottom cylinders appears to be less than half of this, since up to January, 1940, these cylinders had run for the following periods without showing signs of requiring to be re-lined: No. 1 engine, 148,000 hours; No. 2 engine, 147,600 hours; Nos. 3 and 4 engines, each 126,000 hours.

Although the particulars given above are informative, since particulars of wear in the cylinders of engines with blast-furnace gas as fuel are relatively scarce, they do not compare so well with present-day Diesel engine experience as do the figures relative to the wear in the second of the installations mentioned earlier, viz., the 600-h.p. engines running on wood-fired producer gas. This installation is situated in the power station of a gold mine in South America, and the six engines of which it consists are identical. Each engine has six cylinders, 17 in. in diameter by 21 in. stroke, and develops the stated horse-power at a speed of 273 r.p.m. There are six cranks and the pistons are of the trunk type, the piston conditions being very similar to the firm's Diesel engines of the same size, except that oil-cooled pistons are used in these latter engines. The 600-h.p. engines have been at work for some 11 years. Particulars of liner wear for five of the engines are given in Table I, opposite. For No. 3 engine the wear on all the cylinders has been recorded, the average wear on cylinders No. 1, No. 2, No. 4 and No. 6 being 0·00077 in. after 1,000 hours running, and on cylinders No. 3 and No. 5, 0·00048 in. for the same period. For No. 6 engine, wear on five cylinders has been

MOTOR-DRIVEN CONTINUOUS-CHAIN SAW.

MR. JOHN T. PICKLES, HEBDEN BRIDGE.



recorded, the remaining cylinder having been fitted with a new liner and there being no figures available. The rate of wear on four cylinders is after 15,000 hours running, and that on one cylinder after 8,000 hours. The figures show that in the early life of the liner the wear per 1,000 hours averages 0·00056 in.

The engines have run for 70,000 hours, and although new liners have been fitted the original pistons are still in use. After 70,000 hours running the piston-

TABLE I.

Engine No.	Cylinder No.	Number of Hours Run.	Amount of Liner Wear. In.
1	1	47,334	0·048
	6	48,172	0·054
2	6	39,770	0·046
3	1	42,722	0·034
	2	42,722	0·029
	3	18,608	0·012
	4	42,722	0·026
	5	28,046	0·015
	6	42,722	0·042
4	1	46,320	0·045
	2	47,208	0·041
6	1	15,304	0·007
	3	15,304	0·008
	4	15,304	0·009
	5	8,622	0·005
	6	15,304	0·010

TABLE II.

Cylinder No.	Top Ring.	Centre Ring.	Bottom Ring.
1	0·015	0·011	0·008
2	0·014	0·010	0·007
3	0·014	0·010	0·008
4	0·016	0·009	0·008
5	0·016	0·010	0·009
6	0·018	0·010	0·010

ring groove clearances on No. 3 engine were as shown in Table II. These dimensions are the total clearances, and since the rings were originally given a clearance of 0·003 in. the actual wear is that appearing in Table II less the original amount. It may thus legitimately be assumed that the pistons are still quite good for more than another 70,000 hours running. It may be here noted that there would appear to be a discrepancy between the horse-power and size of the engines of the two installations dealt with. This, however, is only apparent and not real, since, owing to the higher calorific value of the producer gas, the engines using it as fuel are rated at 20 per cent. higher than the engines running on blast-furnace gas.

SHIP AND BOAT BUILDERS' EXPORT GROUP.—A Ship and Boat Builders' Export Group has been formed with Mr. N. W. Pragnell as chairman and Messrs. Madox, Petter and Company as secretaries. The address of the office is Ling House, 10-13, Dominion-street, London, E.C.2.

ELECTRICALLY-DRIVEN CONTINUOUS-CHAIN SAW.

THE utility of the portable power-driven saw for dealing with heavy timber has long been recognised, for whether it be employed in the forest, timber yard or sawmill, it is obviously more expeditious to take a portable saw to a log than to convey the log to a fixed saw. A petrol-driven continuous-chain saw of the portable type, manufactured by Mr. John T. Pickles, Hebden Bridge, was described and illustrated in ENGINEERING, vol. 138, page 634 (1934), but Mr. Pickles has also developed an electrically-driven saw, as experience has shown that a current supply is now often readily accessible. The new saw is shown in the accompanying illustration, and is known as the "Lynx" electric chain saw. The chain formed with the saw teeth runs at a speed of 1,200 ft. per minute over a grooved bar or saw frame, which is straight on the top or return edge and curved symmetrically on the bottom or cutting edge, being deepest at the centre, though from the angle at which the photograph reproduced was taken it might be assumed that it was deeper at one end than the other. The frame may be of any desired length between 20 in. and 108 in., different lengths of frame being interchangeable in the sawhead, which has a convenient gripping device. The saw chain runs easily over the rounded end of the frame at its outer end, and is driven by a roller-toothed sprocket wheel at the head. The handle seen to the right of the figure is for guiding and applying feed pressure. It can be readily removed so that, should the saw become stuck by the closing in of the cut it can be withdrawn by a pull in the longitudinal direction.

The form of the saw tooth is noteworthy. Short single-tooth links are apt to "kick" in the cut—a difficulty which has been overcome by forming a single tooth on the inner link and a single thin tooth on each of the outside connecting links. The central tooth makes the first cut and is immediately followed by the double teeth, so that two links make the complete cut. The double teeth have a "set" on alternate outer links. This arrangement, while being very efficient, does not result in an abnormally wide cut, the "kerf" being, as a matter of fact, under $\frac{1}{16}$ in. wide. The motor preferably runs on three-phase current at 400/460 volts, and either 25 cycles, 50 cycles, or 60 cycles, but a direct-current motor can be fitted if desired. The power required naturally varies with the length of the frame; thus, for a 30-in. saw a 3-brake horse-power motor is suitable, a 5-brake horse-power motor being needed for a 48-in. saw. The drive between the motor and the sprocket spindle is by means of a wide flat belt having a tensioning device. The belt is provided with a guard as shown in the illustration and the motor is mounted on a light steel frame with carrying handles. A special feature of this frame is, however, not apparent in the figure, this being a stiff quadrantal plate attached to the back. This allows the saw to be tilted for operation with the quadrant resting on the ground, and is particularly convenient with the larger and heavier sizes. The approximate weight of the new saw is 90 lb. for the 30-in. size; 130 lb. for the 48-in. size; and 160 lb. for the 72-in. size. As regards performance, we understand that the saw will cut through a pitch-pine baulk 12 in. square in 20 seconds. A log of elm 20 in. in diameter can be parted in 30 seconds, the same time being required for the cutting of a log of pine or fir 36 in. in diameter.

NOTES ON NEW BOOKS.

English-Turkish Technical Dictionary. By DR. LYNN A. SCIPIO, M.E. Istanbul: Tsitouris Brothers.

THIS, the first English-Turkish technical dictionary to be published, has been compiled by the Dean of the Robert College Engineering School in Istanbul, and is yet a further example of the rapid progress of Turkey as an industrial nation. Although only a pocket-size volume of some five thousand words, the dictionary contains terms and expressions covering most engineering subjects, with special emphasis on the mechanical, civil and electrical branches. In a foreword to the dictionary the author explains that it was mainly designed for the use of Robert College technical students, and hopes that others dealing with English to Turkish translation will find it useful. There is no doubt that they will, as the great interest that this country has taken in recent years in the industrial development of Turkey has shown the necessity for an English-Turkish technical dictionary. The need has been seriously felt by the technicians of both countries, and it is gratifying, therefore, that Dr. Scipio has taken the initiative in compiling this volume. Since the late Atatürk substituted Latin characters for the Arabic ones in the Turkish language and made it entirely phonetic, it has become an easy matter for foreigners to pronounce Turkish words, especially as most technical terms in use are adaptations from the French, English or German. It would have been helpful to the casual user, however, if some indication had been given of the pronunciation of certain of the special characters. In publishing this dictionary, Dr. Scipio has set a standard of technical translation from English to Turkish which previously was lacking. It is to be hoped that its success will encourage him to publish a Turkish-English technical dictionary in the near future.

Strength of Materials. By DR. ARTHUR MORLEY. Ninth edition. London: Longmans, Green and Company. [Price 15*s.* net.]

IN the 32 years that have passed since the first edition of this standard work appeared, there have been considerable developments in the knowledge of strength of materials, and in the variety and the range of utility of the materials themselves. The amount of research that has been carried out in connection with fatigue, and creep under high-temperature conditions, for example, now represents a large volume of data, the compression of which into manageable compass calls for a labour of examination and selection hardly to be gauged by the appearance of the final result. Dr. Morley states, in his preface, that various chapters and articles have been rewritten, notably those on fatigue, the criteria of elastic strength, creep, metallurgical developments of ferrous metals, and methods of testing; but it is evident from a detailed perusal of this edition that the process of revision has been even more thorough than these instances indicate. The footnotes alone are a valuable work of reference to much authoritative matter in technical and scientific periodicals.

The general scope of the book is represented by the engineering degree requirements of universities and the qualifying examinations of the senior institutions; but there is a practical quality throughout, which ensures that it will not be laid aside when the particular qualification has been attained. The text has been entirely reset and the line illustrations are clear, though some of the diagrams might have been made larger, with advantage. Several of the half-tones, however, leave something more to be desired, being either reproductions of half-tone figures or catalogue blocks. There is a chapter on special materials, such as cement, brickwork and timber, which is a useful summary; and an appendix, discussing the distribution of tensile stress in a plate perforated by a single circular hole, which is based on an investigation by Professor R. V. Southwell. To commend so well-tried a work is almost superfluous; it is sufficient to say that the revision has been carried out with all the thoroughness that is characteristic of Dr. Morley's work.

RESEARCH ON GREY CAST IRON AT BATTELLE INSTITUTE.—A Grey-Iron Research Institute has recently been organised at the Battelle Memorial Institute, Columbus, Ohio, U.S.A., to engage in scientific research and technical development work for the grey-iron industry. A commencement is to be made on the investigation of the fundamental principles of the cupola melting of grey cast iron, with a view to providing data relating to the more accurate control of metal quality and composition. The programme of research will be under the direction of Dr. C. H. Lorig, the supervising metallurgist of the Institute, and Mr. R. A. Sherman, the head of the fuels division. Mr. John Lowe, foundry engineer of the Institute, will act as liaison and development officer.

LABOUR NOTES.

BETWEEN July 15 and August 12 there was a decrease of 27,814 in the number of unemployed persons on the registers of employment exchanges in Great Britain. There was a reduction of nearly 50,000 in the numbers of men and women registered as unemployed, but the numbers of boys and girls rose by nearly 22,000, owing mainly to the registration of juveniles who had reached the school-leaving age at the end of the summer term. The total of 799,452 persons registered as unemployed at August 12 was 432,240 less than the figure for August 14 last year. There were reductions in unemployment in the distributive trades, dock and harbour services, building and public works contracting, tailoring and dressmaking, hat and cap manufacture, hotel and boarding-house services, the entertainments and sports industries and shipping service. On the other hand, there were increases in unemployment in pottery and earthenware manufacture, the woollen and worsted industry, the hosiery industry and boot and shoe manufacture.

Of the 799,452 persons on the registers at August 12, 613,156 were wholly unemployed, 154,380 temporarily stopped, and 31,916 normally in casual employment. Of the wholly unemployed, 303,979 were men, 27,168 boys, 235,192 women and 46,817 girls; of the temporarily stopped, 75,407 were men, 2,603 boys, 71,993 women, and 4,377 girls; and of the casual workers, 30,265 were men, 91 boys, 1,554 women, and 6 girls.

Between July 15 and August 12, the numbers of unemployed persons on the registers decreased by 11,363 in the London area, 1,053 in the Eastern area, 8,660 in the North-Western area, 11,074 in Scotland, and 5,108 in Wales. They increased by 679 in the Southern area, 547 in the South-Western area, 3,191 in the Midlands, 4,404 in the North Midlands, 392 in the North-Eastern area, and 231 in the Northern area. As from July 22, employment exchanges in parts of Kent and Sussex which up to that date were within the Southern area, have been transferred to the London area. The figures given relate to these divisions as now constituted.

An official communication circulated last week stated that the President of the Board of Trade and the Minister of Labour and National Service have given joint consideration to the problem presented by the need for maintaining an adequate supply of skilled labour for the essential branches of the export trade, while at the same time enabling the insistent demands of munitions production for such labour to be met. They emphasise the fact that one of the main "bottlenecks" in the production of munitions of war is skilled labour. All producers of munitions are continually being pressed to adopt measures for effecting the utmost economy in the use of skilled labour so as either to reduce their demands for such labour or to set it free for employment elsewhere. It is essential, they say, that exporting firms should apply the same principles to the full, and it is the duty of the Labour Supply Inspectors of the Ministry of Labour and National Service to ensure that this is done.

Inspectors of Labour Supply have been instructed to secure the agreement of the employer wherever possible before taking any particular employee away from him. It has been laid down that both the employer and the employee shall have at least four days' notice during which either party may make representations against the proposed transfer. When agreement has not been reached the employer, if he is engaged in the export trade, should make his representations to the Board of Trade representative on the appropriate Area Board, who will consult the Divisional Controller of the Ministry of Labour and National Service. It is the desire of both Ministers, it is added, that there shall be as little disturbance as possible to skilled labour which is essential to the export trade. It must, however, be realised that occasions may arise when the demands for labour for munitions of war must take precedence of all others, and in such cases the Board of Trade representative may not be able to secure any concession. Instructions in the above sense are being issued to the officials of the Ministry of Labour and National Service concerned.

The National Arbitration Tribunal has decided against a claim for a war bonus of 15*s.* a week for agents of the Co-operative Insurance Society, Limited, submitted to it by the National Union of Distributive and Allied Workers. The award, it is stated, is without prejudice to the general question of war bonuses to insurance agents. It is pointed out that the Society has increased the guaranteed weekly minimum of its agents since the outbreak of the war.

Of the many and diverse effects of the war on Canadian economy, none, according to the August issue of the *Bulletin* of the Royal Bank of Canada, is "more worthy of note or productive of greater satisfaction than the changed trend in the Canadian employment situation." Employment conditions during 1940—on the basis of the average for the first four months of the year—were considerably better, the number of wage earners at work surpassing even that for 1929, the peak year. It is estimated, moreover, that, at April this year, the total of 473,000 unemployed wage earners had been reduced by 106,000 to 367,000, constituting the smallest labour reserve reported for the month of April in a decade. While the higher level of employment has, as yet, caused no general scarcity of labour, many industries report a serious shortage of skilled artisans.

Writing in the September issue of the *Transport and General Workers' Record*, the journal of the Transport and General Workers' Union, Mr. Arthur Deakin, the acting-general secretary of the organisation, says that "arising from the agitation against the wages being paid to the workers, the Ministry of Labour and National Service has ordered a census to be taken of the wages paid in the essential industries." He has no doubt, he adds, that the investigation will "reveal that the wages paid are very moderate, particularly if they are related to the hours worked—very often twelve hours a day with a seven-day week."

It is difficult to understand, Mr. Deakin observes, why women should be singled out for particular attention in respect of the wages they earn. "Their wages and conditions are," he says, "regulated under a special war-time agreement, which provides that they shall be paid the rates appropriate to the nature of the work they perform. In that agreement, the principle is laid down that where a woman is able to carry on without supervision or assistance the work of the man she is replacing, whether it be day work or piece work, she shall be paid the rate for the job. Surely, there is nothing wrong in the requirement that women doing equal work to that of men shall be paid an equal rate? After all, it is the value of the work that must count and not the sex of the individual carrying out the operation."

Mr. Deakin urges "those who are indulging in wage-cutting propaganda" to pause and consider before advocating a policy and creating an opinion which can only result in producing an outlook and reaction which will endanger our national unity." "Let them not," he continues, "pursue a policy which is likely to produce that class warfare which they have so long and vociferously denounced. In point of fact, there never has been any class warfare in this country coming from the working classes and there never will be if the worker is given proper consideration in the economic life of the country. The Trade Union Movement stands four-square in its refusal to allow any attack of this character to influence its policy. . . . No fair-minded person would attempt to deny that the workers are responding generously to the great calls being made upon them, and they will continue to do so so long as they feel they are getting a square deal."

The National Railway Administration of Mexico offers special rates at 50 per cent. of the regular fares to all workers and public employees who wish to take vacation trips on the National Railways network. Beginning on January 1, 1939, low fares were offered at certain seasons when most workers took their vacations, but now the vacation trip may be taken at any time of the year. The reduced fares apply also to two members of the worker's family travelling with him—two women of any age, two males under 18 or over 55 years of age, or any combination of these groups. The Mexican National Railways are owned by the Government, but administered by the workers.

The Trade Union Congress is to open at Southport on October 7 and continue for three days. Owing to the limited time available, the attention of the delegates will be concentrated on the General Council's report and the agenda of resolutions from affiliated unions. Among the resolutions of which notice has been given is one calling for the complete removal of the permanent black-out in all workshops. Six resolutions call for legislation to repeal the Trade Disputes and Trade Unions Act of 1927 and to place the unions in a legal position not less favourable than they held before that measure was enacted.

UNITED STATES STEEL INDUSTRY.—The production of steel ingots in the United States in the last week of August is stated to have been equivalent to 91·3 per cent. of the capacity of the steelworks. This constitutes the highest figure so far recorded this year. A high record figure of 94·4 per cent. was attained in the final week of November, 1939.

FATIGUE AND STATIC FAILURE.*

By PROFESSOR H. W. SWIFT, M.A., D.Sc.

IF the conditions of loading are fluctuating, it is only logical to base any factor of safety on the strength of the material under fluctuating stress: in other words, on the appropriate fatigue limit. The frequency of fluctuation necessary to qualify for fatigue consideration is really quite small. A turbo-shaft running continuously at 3,000 r.p.m. undergoes over 1,500 million stress cycles a year, an engine or machine performing only 60 cycles a minute and working only 40 hours a week completes over seven million cycles a year, and even a railway bridge carrying a train every 5 minutes will be subject to a million cycles in ten years. Moreover, the form of the familiar fatigue test curve shows that the stress which will cause fatigue failure in one million cycles is not 10 per cent. greater than a stress which would be safe for an indefinite period. It is, therefore, evident that the fatigue limit is the logical basis for design over a very wide range of machines, and is also appropriate for some structures.

If, on the other hand, the stress fluctuations are small or very infrequent, the proper basis for calculation is some static property of the material, which clearly depends on the kind of stress and also to some extent on the kind of material. In the case of a ductile material it is possible to work either on the ultimate strength or on the elastic limit. Where permanent deformation would destroy the usefulness of the machine or structure, the elastic limit is the logical basis. This condition prevails in the great majority of cases. On the other hand, in cases where overstrain has no serious consequences, or where it may even induce a readjustment tending to strengthen the machine or equalise stress differences, there is a valid case for use of the ultimate strength. Chains, coupling-rods and thick cylinders are cases in point. The adoption of the elastic limit with ductile materials has certain definite advantages from the standpoint of convenience in design, for it is now generally accepted that the elastic limits in tension and compression are substantially equal to one another and are dependent on and just about twice the value of the elastic limit in shear, so that in design calculations based on the elastic limit the only stress which really need be computed is the principal shear stress. In the case of a brittle material such as cast iron, the ultimate strength is the only possible criterion, and since the shear strength of cast iron is about double its tensile strength, the tensile stress and tensile strength are the important quantities for comparison, except in cases of pure compression, which are rare.

When applying the fatigue limit in design it is necessary, of course, to consider the range of stress as well as the maximum stress involved. A great deal of experimental work has been carried out on this subject, both under direct and torsional stresses, and although the results vary as between different materials in a not very systematic way, a general rule which errs on the side of safety and has the great merit of simplicity can be based on what is known as the Goodman diagram and is indicated in Fig. 1, opposite. It varies from Goodman's diagram only where the mean stress is compressive, under which conditions the fatigue range is taken as constant. In the Goodman diagram, or for that matter any of the other diagrams which have been put forward to correlate fatigue ranges, it will be noticed that the limiting or vanishing point is the ultimate strength of the material, and that the elastic limit does not come into the picture. This is due, of course, to the fact that, under ordinary rates of stress alternation, there is not time for plastic strains to develop, stress concentrations are not relieved, and the stress-strain relationships are elastic throughout. It only becomes a matter of concern when we try to link up rationally the working stresses under fluctuating loads with those under steady load, which may be based on the elastic limit.

The modification of Goodman's diagram shown in Fig. 1 is submitted as a basis of calculation for both direct and shear-stress conditions, since it has been found that the general relationship between limiting stress range and mean stress is similar for direct and shear-stress cycles and for ductile or brittle materials. For ductile materials, the range in shear is found to be rather more than half the range in direct stress, so that the Goodman diagram for tensile fatigue can safely be applied for shear conditions if the stress scales are halved. For less ductile materials the range in shear bears a greater proportion to the range in direct stress, and for a brittle material like cast iron, since failure, even under pure shear, actually occurs by tension, the Goodman diagram can be applied with the same scale, whether in shear or direct stress.

* Excerpt from Presidential Address on "Mechanical Properties in Relation to Design," delivered to the Sheffield Section of the Junior Institution of Engineers on March 1, 1940. Abridged.

In cases of combined stress due to bending and torsion, the conditions of failure by fatigue have been examined by Gough and Pollard. It should be mentioned that in their experiments the torsional and bending stresses were always proportional to and in phase with one another, and so fulfilled a special relationship which does not generally hold in practice. Gough and Pollard found that, when a ductile material is subjected to reversals of combined stress in this way, the combinations of normal stress n and shear stress s on the transverse planes which will just cause fatigue failure are related by the equation :

$$\left(\frac{n}{n_1}\right)^2 + \left(\frac{s}{s_1}\right)^2 = 1,$$

where n_1, s_1 are the fatigue limits in pure tension and pure shear, respectively. If, therefore, the conditions of bending are such that the ratio of the shear stress s (due to torsion) to the normal stress n (due to bending) is known, $\frac{s}{n} = r$, and if the ratio of the fatigue limits under shear and normal stress is known, $\frac{s_1}{n_1} = m$, then it follows that fatigue failure will occur if

$$\left(\frac{n}{n_1}\right)^2 \left(1 + \frac{r^2}{m^2}\right) = 1.$$

Hence this problem of combined stress reversal may be treated as a case of simple reversal of normal bending stress if an equivalent fatigue limit =

$$\frac{n_1}{\sqrt{1 + \frac{r^2}{m^2}}}$$

is used in place of n_1. Alternatively, an equivalent fatigue bending moment may be used for fatigue purposes :

$$M_f = M\sqrt{1 + \frac{r^2}{m^2}}$$

and the shaft may then be designed as a beam subject to reversals of bending stress alone. The value of m for ductile steels appears to be about 0·55 to 0·7, the lower limit corresponding to mild steels. If we assume a representative value of $m = 0{\cdot}58 = \frac{1}{\sqrt{3}}$, we find that the equivalent bending moment for fatigue purposes is then :

$$M_f = \sqrt{M^2 + \tfrac{3}{4}T^2},$$

where M is the actual bending moment and T the actual twisting moment.

When applying these results to the practical problem of combined bending and torsion in a shaft, a certain amount of caution is necessary. The conditions in this case do not generally involve a concurrent reversal or fluctuation of both bending and torsional stresses ; the torque may remain constant while the bending is reversed, as in the case of electrical and turbo machinery, or the torque may vary in quite an independent way to the bending, as in the case of engine crankshafts. In either case, the planes of principal stress and the planes of principal shear stress are constantly changing during a cycle and simple reversal does not occur on any plane in the shaft. The full analysis of each case is a tedious matter, but it may be mentioned that, in the case of a shaft carrying a constant torque and a reversing bending moment of the same maximum value as the torque, the planes which carry the maximum tensile stress have a range of direct stress from this maximum to a smaller compressive stress and a range of shear stress from zero to the maximum.

The principle to be observed in considering what range of values can reasonably be applied in computing a factor of safety is that, under no conceivable conditions, must the stress rise to the limiting value. The guarantees against this occurrence must naturally be greater in cases where the consequences of failure would be serious. For example, any undue local concentration of stress above the fatigue limit in a member subject to repeated stress is bound to lead to ultimate fracture, while local concentration above the elastic limit under static stress might, in a ductile material, be accommodated by local plastic flow. In the same way the breaking of a chain or link, or the bursting of a boiler, would have more serious consequences than the yielding of a valve stem, or the bending of a connecting rod, and the replacement of the whole of a complicated machine frame would be more costly than the fitting of a new part if the frame were designed as an assembly. These largely incommensurable factors are matters for the consideration of the designer in each case, and obviously cannot find their place in any general rule.

(*a*) *Static Conditions.*—With static loading and a ductile material, it is a common practice to allow a factor of safety of two on the elastic limit (or lower yield point). This assumes that the maximum loading conditions can be tolerably well predicted, that no serious difficulties exist in the stress calculations, and that the opportunities for stress concentration are not abnormal. In the case of a complex construction, owing to the increased liability to internal stresses, the factor should be somewhat greater. On the other hand, in cases where stress calculations are reliable, and where stress concentrations can be allowed for, the factor may justifiably be reduced. It is known, for example, that the effect of a standard keyway is to diminish the fatigue strength of a shaft by about 20 per cent., and it is known that double butt straps for the longitudinal joints in boiler shells can be made with an efficiency of 84 per cent. Such knowledge reduces the margin of uncertainty and enables the factor of safety to be kept down. With live loads of an infrequent kind, either the factor of safety may be increased or, preferably, an equivalent static load can be estimated in the light of the prescribed conditions.

With static loading and a brittle material, or a material having no marked limit of elasticity, the dangers of internal stresses and stress concentrations are greater, the properties of the material at the crucial points are often less well known, and the consequences

Fig.1. FATIGUE RANGES

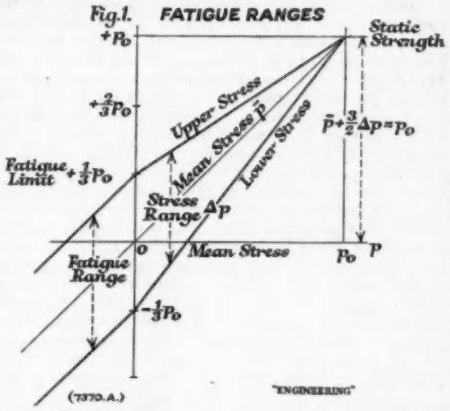
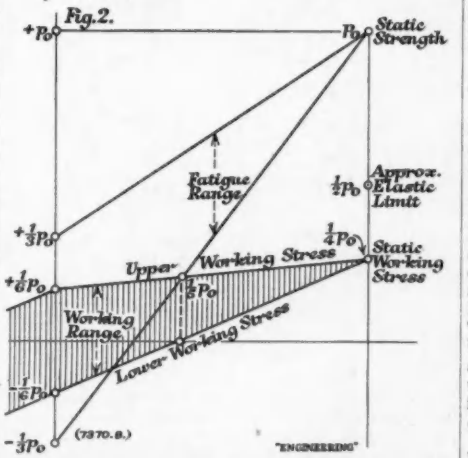


Fig.2.



of failure are often more expensive than with elastic breakdown. Hence, larger factors of safety are employed, varying as a rule from 4 to 8 and based, of course, on the ultimate strength. Under static conditions of combined stress, since the elastic failure in ductile materials occurs usually by shear while the fracture in brittle materials occurs by tension, it is logical in the former case to calculate the greatest shear stress due to the combined system, and to allow a basic factor of safety of 2 as before on the elastic limit, and in the case of the brittle material to calculate the greatest tensile stress and employ a factor of safety in the higher range of 4 to 8 on the ultimate strength. Under conditions of repeated loading, the working stresses must clearly be based on the Goodman or a similar fatigue diagram. But, since the maximum stress may be determined by different conditions from the range of fluctuation, it may not be satisfactory to apply a single factor of safety for both, certainly not for the maximum stress alone.

In the particular case of reversed stress, where the mean stress is zero, it has been found by experience that, where proper account is taken of probable stress concentrations and where the design is such that these are not excessive, a factor of safety of two on the fatigue limit, which is substantially the same as a factor of safety of six on the ultimate strength, is a satisfactory allowance. On the other hand, it has been found that stress concentrations due to sharp corners, for example, may reduce the fatigue range by anything up to 30 per cent., and in cases where such concentrations are unavoidable, and not readily allowed for, the factor of safety should be proportionately increased, up to, perhaps, eight on the ultimate strength. Where a member is subject to reversals of combined stress, the same range of factors of safety as have been based above on the normal fatigue limit may in this case be based on the "equivalent fatigue limit," or alternatively, the fibre stress due to the "equivalent fatigue bending moment" can be limited to the working fatigue stress under direct stress conditions.

(*b*) *Fluctuating Stresses.*—The problems of fixing working stresses under cyclic stress of other ranges than simple reversals cannot properly be solved by applying the same factors of safety for all ranges, since a factor (such as two), which would give safe conditions under simple reversal, would give an unsafely high upper limit of stress under relatively small fluctuations. Indeed, in the limit when these fluctuations were negligible, the working stress would be one-half the ultimate strength of the material. A more reasonable range of working stresses can be founded on a linear diagram (such as Fig. 2, herewith) similar to Goodman's, but connecting the working stress for reversals with the working stress for static conditions. In the case of mild steel, the normal factor of safety of two on the elastic limit is approximately equivalent to a factor of four on the ultimate strength, and the working stress diagram then takes the form shown shaded in the figure. It will be seen that this suggests normal factors of safety on ultimate strengths of four, five or six, according as the stress is steady, repeated from zero, or reversed. For purposes of more general calculation, it may be pointed out that, if the mean stress bears a ratio of r_1 to the static working stress and the range of fluctuation a ratio r_2 to the range of working reversed stress, then the proper working stresses according to the linear diagram are such that $r_1 + r_2 = 1$. But a simple straight-line sketch will probably be of more real help to the designer than such a formula.

In all cases of reversed bending combined with torsion, the stress fluctuations are large compared with the mean stress, so that the conditions never approach those of static stress, and it is therefore justifiable to base calculations on the more normal Goodman diagram (Fig. 1). According to this diagram, if $\bar{p}$ is the mean stress and Δp the full range of stress on any plane, then if this plane is under limiting fatigue conditions the ultimate stress p_o for the material will be : $p_o = \bar{p} + \frac{3}{2}\Delta p$, so that the sum of the two terms $\bar{p} + \frac{3}{2}\Delta p$ affords a criterion of the liability to fatigue failure on the plane under consideration. Where, therefore, failure is possible on any of a number of planes, that plane for which the expression $\bar{p} + \frac{3}{2}\Delta p$ has its greatest value is the most severely stressed, and should form the basis of design. An important example of cyclic stress in which simple reversals do not occur arises in cases where torsional and bending stresses both occur, but do not fluctuate with one another. These cases fall into two main groups, namely, (1) where the torsion is constant while the bending is reversed, as in the case of a motor or turbine shaft ; and (2) where the torsion and bending both fluctuate or reverse, but in a different cyclic manner, as in the case of a crankshaft.

In group (1), where the torsion is constant, it can be shown on theoretical grounds that the effect of this superimposed constant torsion on the fatigue strength in simple bending is remarkably small so long as the twisting moment does not exceed about twice the maximum bending moment, and this result has been demonstrated experimentally by Lea and other workers. Even in a case where the twisting moment is twice the maximum reversed bending moment, the shear stress criterion $\left[\bar{s} + \frac{3}{2}\Delta s\right]$ is only 20 per cent. greater and the normal stress criterion $\left[\bar{n} + \frac{3}{2}\Delta n\right]$ only 10 per cent. greater than with no twisting at all. In the more general case the constant torque can be taken into account by employing either an equivalent fatigue bending moment :

$$M_f = \frac{M}{2}\left\{1 + \sqrt{1 + \left(\frac{T}{3M}\right)^2}\right\}$$

or an equivalent fatigue twisting moment :

$$T_f = T\sqrt{1 + \left(\frac{T}{3M}\right)^2}$$

and basing the calculations on normal or shear stress, respectively.

In group (2), where the torsion and bending are subject to non-conforming fluctuations or reversals, the problem of identifying the planes on which the most unfavourable stress ranges occur can usually only be solved by a process of trial in which stress range

calculations are made for various planes, and these calculations may conveniently be based on the criterion $\bar{p} + \frac{3}{2}\Delta p$ already discussed.

These ranges, of course, will primarily be either ranges of normal or of shear stress considered separately. For a more complete analysis it is desirable to find the most unfavourable range under combined stress by making use of Gough and Pollard's elliptical formula. First, the equivalent range for reversed normal stress is computed for any leading planes :

$$n_0 = \frac{\bar{n}}{3} + \frac{\Delta n}{2}$$

and the corresponding equivalent range for reversed shear stress :

$$s_0 = \frac{\bar{s}}{3} + \frac{\Delta s}{2}$$

These stresses cannot, of course, be given numerical values in the first instance, but are expressed in terms of the undetermined diameter of the shaft, and actually vary inversely with the cube of this diameter.

An appropriate criterion for the severity of stressing on different planes is found by substituting the values of the equivalent normal and shear ranges in the elliptical formula :

$$\frac{n_0^2}{n_i^2} + \frac{s_i^2}{s_i^2}.$$

The plane giving the greatest value of this expression is the most severely stressed plane and therefore the one on which the design should be based. If the stresses were chosen so as just to reach the fatigue limit, the numerical value of this expression would be unity (in accordance with Gough and Pollard's formula), and, in order, therefore, to allow a factor of safety of two on the fatigue limit, the stresses must be so chosen that :

$$\frac{n_i^2}{n_i^2} + \frac{s_0^2}{s_i^2} = \frac{1}{4}.$$

Since n_0 and s_0 are both known in terms of $\frac{1}{d^3}$, this equation is a simple equation in d^6 and the necessary working diameter is immediately found.

LIQUEFIED PETROLEUM GASES IN THE UNITED STATES.

THE fact that bottled gas, as the liquefied petroleum gases are called, is increasing in popularity in the United States is indicated in a report issued by the Bureau of Mines at Washington. The gas, which consists of propane, or butane, or a mixture of the two, is used as a fuel for cooking, heating and lighting, and in connection with air-conditioning and refrigerating installations in rural districts outside the areas served by municipal gas undertakings. Propane and butane and a third gas, pentane, are also employed as solvents and for other purposes by the chemical-manufacturing industry, while propane-butane mixtures are used, to some extent, as fuels in internal-combustion engines. The liquefied gases are transported in bulk, in tank wagons and lorries, but smaller quantities are supplied to individual farmers and householders in cylinders. The Bureau of Mines report shows that sales of liquefied petroleum gases have increased steadily from 1933, when they totalled only 38,931,000 gallons, to 1939, when 223,580,000 gallons were disposed of. Out of this last total, 87,530,000 gallons, or 39·2 per cent., were consumed for various domestic uses, compared with 35 per cent. of the total in 1938 and 29 per cent. in 1937. Further, out of the total for 1939, upwards of 62,300,000 gallons, or 27·9 per cent., were used as internal-combustion engine fuel, undertakings ; 26,892,000 gallons, or 12·0 per cent., were purchased by chemical manufacturing firms ; and quantities aggregating 29,792,000 gallons, or 13·3 per cent., were used as internal-combustion engine fuel. With the exception of that employed in chemical manufacture, all these quantities show considerable increases as compared with 1938. Liquefied butane and propane are exported, but this market appears to be somewhat erratic ; thus, while the total shipped in 1937 was 1,984,000 gallons, the figure for 1938 was 825,000 gallons, and that for last year 1,570,000 gallons. In 1939, France took 566,000 gallons, Mexico 517,000 gallons, and Canada 420,000 gallons.

WORLD PRODUCTION OF TIN.—According to statistics quoted in the journal *Tin*, the world production of tin in July totalled 18,800 tons, compared with 20,100 tons in June. This brings the total production for the first seven months of the current year to 124,400 tons, against 77,600 tons in the corresponding period of 1939.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

ABSTRACTS OF SPECIFICATIONS RECENTLY PUBLISHED UNDER THE ACTS OF 1907 TO 1939.

The number of views given in the Specification drawings is stated in each case ; where none is mentioned, the Specification is not illustrated.
Where inventions are communicated from abroad, the Names, etc., of the Communicators are given in italics.
Copies of Specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery-lane, London, W.C.2, price 1s. each.
The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.
Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

ELECTRICAL APPARATUS.

521,675. Metadyne Transformer. Metropolitan-Vickers Electrical Company, Limited, of London, H. Newsam, and A. Tustin, of Sheffield. (11 *Figs.*) November 24, 1938.—The invention is a simplified arrangement of the stator windings which allows of a considerable reduction in the number of coils per pole. The metadyne transformer shown is a one-cycle machine, with a two-pole rotor, four poles A, B, C, D on the stator and four brushes. The positive direction of the primary current passing through the rotor is from *a* to *c* (Fig. 3) and the positive direction of the secondary current is from *b* through the rotor to *d*. Each stator pole has hitherto carried a primary stabilising coil S^1, a secondary stabilising coil S^2, a regulating coil R supplied from a shunt-wound exciter, and a variator coil W for controlling the secondary current. The resultant flux due to the primary current circulating in the rotor windings and to the stabilising excitation is shown in Fig. 1, the stabilising and the rotor ampere turns being made of such a value that the primary rotor ampere turns and the primary stabilising ampere turns on the poles B and D completely cancel. Similarly, Fig. 2 shows the resultant flux set up by the combined secondary rotor and secondary stabilising currents, the ampere turns being chosen so that they cancel on the poles A and C. The variator winding controls the value

Fig.1.

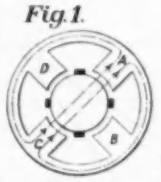
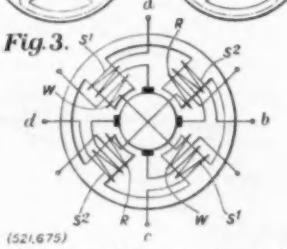


Fig.2.

Fig.3.



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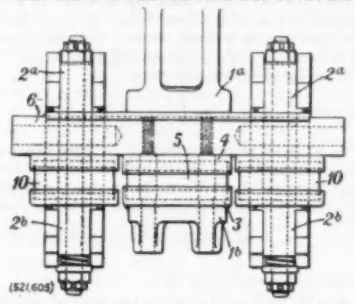
of the secondary current for any given value of the secondary voltage. If one particular secondary voltage is considered, and since the primary voltage is always fixed, there will be definite voltages between the various brushes of the metadyne and hence definite fluxes will be required through the pole pairs B, D and A, C. With the windings arranged so that the secondary current produces ampere turns on the pair of poles B, D only, as shown in Fig. 2, it will only be possible to vary the secondary current by supplying a separate "secondary variator excitation" to these poles alone. Similarly, the primary current can only be varied by providing a separate "regulator excitation" on the poles A, C alone. A further simplification of the field coils can be made by reducing the number of windings which are supplied with primary and secondary current, respectively. Thus, the stator coils S^1 carrying primary current are on the poles B and D only, where their excitation opposes the flux due to the primary current through the rotor windings. By suitable choice of the rotor winding, and the turns on the poles, these ampere turns cancel completely on the poles B and D, leaving a resultant primary flux on the poles A and C only, as shown in Fig. 1. The same arrangement is adopted for the stator coils S^2, which carry the secondary current, these being provided on the poles A and C only, giving a resultant secondary flux as shown in Fig. 2. The combined arrangement is shown in Fig. 3. (*Accepted May* 28, 1940.)

521,605. Traction-Motor Suspension. The English Electric Company, Limited, of London, and E. A. Binney, of Ilkley. (4 *Figs.*) November 21, 1938.—The invention is a rubber suspension for an electric traction motor of the nose-and-axle suspension type. A bifurcated nose 1*a*, 1*b*, projects from the side of the motor, and corresponding members 2*a* and 2*b* project from a transom of the bogie frame. Between a metal cup 3 secured to the part 1*b* of the motor nose and a similar but inverted cup 4, is mounted a block of rubber 5 forming the resilient mounting between the motor and an intermediate horizontal bar 6. A channel-section packing strip is inserted between the bar and the part 1*a* of the motor nose. The bar 6 extends on each side of the motor nose



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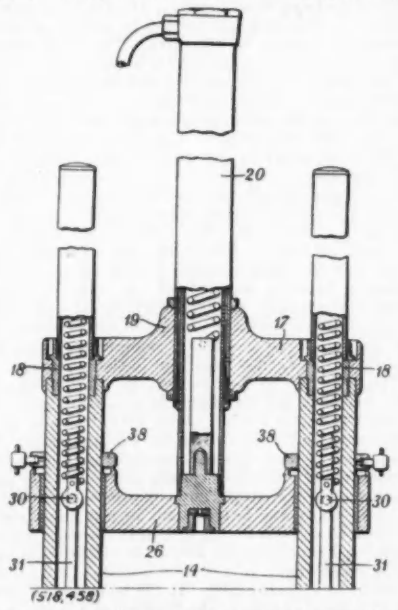
so as to lie between the projections 2*a* and 2*b* from the transom, which are in two pairs one on each side of the motor nose. Between similar metal cups bearing, respectively, against the projections 2*b* and against the bar 6, are further rubber blocks 10 forming the resilient support for the bar on the bogie frame. The whole is held in place by bolts passing right through the projections. The weight of the motor plus the torque reaction for one direction of rotation are taken by the blocks 10. The cross-section of these blocks is larger than that of the block 5 which, when the direction of rotation is reversed, carries a load equal to the torque reaction minus the weight of the motor. For ease of dismantling and assembly, the rubber blocks can be slightly compressed by bolts screwed into the bar 6. (*Accepted May* 27, 1940.)

MACHINE TOOLS AND MACHINE-SHOP EQUIPMENT.

518,458. Broaching Machine. R. T. Shelley, Limited, of Birmingham, and C. Lindall, of Birmingham. (3 *Figs.*) October 3, 1938.—The broaching machine, of which the upper part is shown, has a heavy base plate mounted on a frame of rolled sections. Two hollow steel columns 14 are secured to the base, the upper ends of which support a stationary crosshead 17 secured by sleevenuts 18 screwed into tapped recesses in the ends of the columns. A deep central boss 19 is bored to take the lower end of a hydraulic ram cylinder 20. The ram is a tube and its lower end is screwed on to a boss secured in a crosshead 26 sliding on the columns. The boss to which



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the lower end of the ram tube is secured passes through the crosshead 26 and in its lower end is a socket for the shank of a broach. For the return stroke, a stud 30 in each end of the crosshead works in a longitudinal slot 31 in the column and is connected to a tension spring housed partly in the hollow column and partly in a tubular housing screwed into the sleeve nut 18. A further spring in the ram cylinder is connected to the boss 19, the upper end being secured to the head of the ram cylinder. The upper limit of the stroke of the crosshead is set by adjustable stop collars 38. The oil for the ram is supplied by a pump mounted on the frame. (*Accepted February* 27, 1940.)